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THE OPPORTUNITY OF THE TEACHER IN THE CLASS ROOM.[1]

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A pupil receives many impulses to the study of our science, and his growth rests upon many determining causes. There may be, what is somewhat rare, his own native love of the subject, which will prompt him to independent study. There is the assigned home work, the required outside reading, the aid that he should receive from a good text-book; and there is the artificial stimulus of marks, of unannounced tests, and of the general review forced upon him by the approach of a semiannual judgment day. But greater and far more vital than any one of these, or than all of them put together, is the stimulus he receives from the class room hour.

The teacher has ordinarily from forty to fifty minutes at his disposal from three to five times a week, and, allowing for examinations, for perhaps thirty-two weeks in a year. In these precious minutes he has to deal with a score of boys, that he may help in their transformation, not necessarily into mathematicians, but into rational men. Truly he cannot reflect too often on how to use the time. So I trust that you will be patient if you have to hear some old-fashioned truths, some homely, oft-repeated truths. It pays even our public men, from time to time, to refresh their knowledge of such old-fashioned things as the Ten Commandments and the Declaration of Independence.

The opportunity of the teacher in the class room: this, then, is my theme. We will assume and omit from consideration the mechanical side, suppose the pupils seated, the roll called, the absentees noted, and, yes, the test applied as to whether the boys have their lessons—for this, too, belongs to the mechanical side. The vital relationship of the teacher to the pupil still remains, and it is of this mainly that I wish to speak. A word or so at the outset by way of digression with reference to preparation. It sounds like a commonplace to say that a teacher should be

[1] Read before the Association of Mathematical Teachers of New England, December 9, 1911.

prepared for his work; and yet it is a matter of equally common observation that men and women teach, and continue to teach, without meeting such a requirement. Thorough equipment is fundamental, for only mastery can beget mastery. The mathematics teacher should know the subject with which he has to deal in outline and in detail. He should have searched its length and breadth, have reached to its heights, and sounded its depths. He should have gone to its bounds, yes, and beyond. The danger line is nearly always at the boundary. The teacher's experience is like that of many of the functions with which he has to deal; they behave in a reputable and orderly fashion within the region of their definition—but at the boundaries, beware! The only safe course is to fix the boundaries of one's knowledge far beyond the probable limits set by the demands of one's daily rounds. That introduces the factor of safety, as the bridge builder says. You remember that Kipling's polo pony, the Maltese Cat, won the match because of the demoralizing effect of boundary conditions on his opponents, and many a baseball or football game has been lost at the side lines.

And this preparation should not be a rigid fact, something that was finished far back in college or university days. It should be an active, continuous, vital process, not so much a preparation as a preparing. You know that in the administration of the German *gymnasium* it is expected that the *ordinarius* at least shall usually be engaged in advanced work; when possible, in actual research work. Many notable contributions to the advance of mathematical science have come from the labors of these teachers in secondary schools. But while mathematics has been thus enriched, such work has its chief value in its reaction upon the worker. Among other things—and this is not to be despised as a consideration—the difficulties of investigation in his own advanced work will make him more sympathetic with the attitude of the earnest student toward what is new to him in mathematics. It will enable him to realize that the pupil who cancels the "3" in $3 \sin \frac{x}{3}$ is not necessarily stupid or lazy. It will remind him that new symbols are a new language, and that one is never master of a language when he still feels the need of translation; but only when it has come to be a tool of thought.

But something more is requisite than such a general preparation as has been indicated. The teacher must prepare himself for each individual exercise. He must see it in perspective, de-

fine sharply in his mind what most needs emphasis, see its relation to what has gone before and what is to come after. No familiarity with the subject, no matter how extensive the experience upon which it may rest, will justify the teacher in neglecting such special preparation. A number of years since I was making a short stay in Göttingen, and dropped in at one of Klein's lectures. He was giving his elementary course in the differential and integral calculus. The lecture was the perfection of art. Subsequently, in a conversation with his assistant, I learned, that (according to Klein's own statement) he was putting more time on the course than when he had first given it, many, many years before. That one of the greatest, certainly the most famous mathematical teacher in the world should have thought it worth his while to lavish care and thought on youngsters who had just come up from the *gymnasium*—was illuminating and stimulating.

The stages of preparation behind us, let us now go into the class room and meet our pupils. What shall we do first? Perhaps assign the next lesson. At any rate we should not leave it to the fag-end of the period, or, worse still, till the bell has sounded the recessional. I have actually known teachers who shouted the lesson to their pupils as these were leaving the room. The assignment of a lesson is, in my judgment, one of the most important and serious things in connection with the class room exercise. Connection should be shown with past lessons and that of the day. It may be wise even to assign work for several days ahead, such assignments, of course, being open to modifications as the work progresses. Every writer or speaker knows the importance of getting into touch with his hearers, and one of the very best ways in the case of a connected series of lectures or exercises is by an outline review, a resumé of what has just been studied. Such a resumé should, in many cases, be asked for from some member of the class; but unless the response is entirely successful, the teacher should go over the outline again. Such connected reviews of large, or at least considerable portions of a subject are a source of one of the most admirable disciplines offered by mathematics. President Lowell said last October, at the meeting of the New England colleges and preparatory schools, that while many a student whom he had set at a reading task proved, when called upon, to know a great deal about particular paragraphs, few knew anything about the book. The teacher should make every effort to enlarge the boy's horizon, by ex-

plaining underlying principles and possible classifications of the facts of the science. These things should not, of course, be dogmatically stated (dogmatism has no possible place in our science), but like every conquest of the recitation hour they represent the joint effort of teacher and taught. Indeed, the work of the class room should be before all else coöperative. Did you ever read Dicey, "On the Teaching of English Law at Harvard"? It is a fine tribute, from a man who is himself a great teacher, to an institution of the first rank. A number of years ago, I had the privilege of visiting the school and hearing some of the lectures. I recall very definitely the hour with Dean Ames. It was called a lecture; but such in the usual sense of the term it most emphatically was not. The teacher began by stating briefly but clearly an issue that had been joined, involving a legal distinction. The matter once fairly launched, Dean Ames asked Mr. Hitchcock—I recall the name, as he was an Amherst graduate—to give his own opinion. Mr. H. was followed by Mr. A. and Mr. B., and others, who acquiesced in, modified, or attempted to controvert the previously expressed opinion. It was a series of recitations, bridged over by keen and incisive questions by the dean, every one calculated to inspire thought and to lead to a solution. When this process had gone on for a half hour, perhaps, the teacher closed the discussion somewhat in the way in which a judge sums up the arguments of the counsel in an actual case at law, and states whither the weight of the discussion must inevitably lead. In fine, the students in that class had by joint effort under the guidance of their teacher thought out the law.

This illustrates the fact that the basis of the highest class room efficiency in any subject is the creation in the pupil of the lively sense that under sympathetic, careful guidance he is rediscovering truth. I am aware that such a genetic method, such a method of rediscovering truth, is the intent of most of our best schools and colleges to-day. But if your experience resembles my own, you will confess that we are, all of us, ever falling from grace. It is so easy to err on one side or the other, to lecture, in the literal sense of that term—which is really to dogmatize, or rather to furnish the pupil with ready-made reasoning which he needs only to assimilate and give back in tests; or, on the other hand, to let the exercise degenerate into "hearing the lesson." I have recently read anew an article which appeared in the *Educational Review* in 1903 on "The American College, from the Viewpoint of an Undergraduate." It was written by a man only a

few years out of college, and I can assure you it would interest you along many lines. What impressed me especially in the article this time was its statement that the best teaching must appeal to the will of the pupil, and not merely to his intellect. Such a thought connects up with what has just been said. The highest work of the teacher is to arouse the boy to a habit of initiative, to render him active rather than passive. He must be stimulated to think for himself. His performances in the recitations and tests must be directed so that he will not merely or mainly give back what he has received, but add as well no small quantity of his own thought. If he cannot act solely by his own volition as the result of a self-determining process, he should at least react and not merely reverberate.

A number of years since, Amherst was fortunate in having on its staff for a half year a distinguished English scholar and writer, Professor Woodberry. After some weeks with a class in English literature, he gave his first test. I recall very vividly his despair when he read the papers. "Why," he said, "the men are merely firing back at me my own words." It was a process of regurgitation. His lament was that he had failed, so he thought, to make the men think independently. Our own subject offers, of course, a peculiar advantage in its limitless array of problems, each of which, if they are real problems and not mere examples, offers a fresh field for thought. Yet even here, how disheartening it is to see the attitude of the average pupil toward a problem that is not patterned after a predecessor.

This use of a teacher's opportunity to stimulate thought, rather than to impart information or ready-made thinking, is especially helpful in arousing interest in the subject. The matter of interest is of transcendent importance, as we all know. Now in many departments of school work interest is involved in the subject-matter. This is true, for example, in the case of the natural sciences, and in literature and history; but not so with the average boy or girl in pure mathematics. Our subject is so abstract, so essentially subjective, that its appeal is far from seductive. Any possible interest it may have for the pupil lies, not in its radicals and complex fractions, its determinants and goniometric formulas, but in the pleasure that every normal mind takes in its own exercise. As a boy once put it in my hearing, "It's fun to feel the wheels going 'round." This is above all true when he sets them in motion himself.

I am reminded of an experience that I had many years ago with

a member of one of my freshman mathematics sections. He was apparently a very dull fellow indeed, and his intellectual efforts were still further handicapped by his membership in the football team. Failure succeeded failure, and the case seemed hopeless, until I discovered, by an accident, that he was rarely successful at drawing. We were in solid geometry at the time, among parallelopipeds and pyramids. The famous "Devil's Coffin" figure loomed ahead, a terror not only to my students but to me as well —to this day I cannot draw the figure decently. At the end of the exercise of the day before the monster was to be upon us, I called the student of whom I have spoken to my desk, and told him that I should consider it a favor if he would put the drawing on the board in his best style. The next day we saw arise before our eyes a real work of art, the completion of which was greeted by a round of applause from the men, and by a warm word of appreciation from the desk. The event proved a turning point in the fellow's career. Finding that he could do one thing well, that he was indeed first with no second in one branch of class room activity, it occurred to him that other branches might be worth striving after. For the first time his interest was aroused, and the day of failure was behind him. He was never brilliant, but ever afterward (he elected all the mathematics which the college offered) he did his work substantially and well.

I have instanced this experience in order to emphasize the far-reaching importance of getting a boy interested. But let me digress a moment in order to draw a further inference from the story, one right at hand. It showed me the deep significance of personal contact with the pupil, the importance of individualizing the members of a class. The administration of a school or college should always make this possible, and the last economy should be that which overloads teachers with hours or with pupils.

I said at the outset that a teacher should have a broad, deep preparation, involving years of study and thought; that he should have an immediate preparation for the work of the day. To this may be added that, so far as possible, he should prepare himself for the pupil, guided in this work of preparation by his knowledge of idiosyncrasies, and helped to success by an abundant sympathy with boy nature. The cases are rare when this nature cannot be reached in some way; where there does not lie some avenue of approach to a source of interest in the pupil's mind. For many years now I have been closely identified with college administrative work, and have come into daily contact with many stu-

dents. My experience, though not, of course, without its shadowy side, has left me a confirmed optimist. The average boy intends to do the right thing, even in the performance of his daily scholastic tasks, and the average boy will respond to a frank, self-forgetful, enthusiastic appeal to his better side.

The individual interest of the student, and thus the chief business of the class room hour may be further promoted in the following more formal way. In proving a theorem, or giving the solution of a problem, the student should state his plan of campaign, carrying it clear to the end. Such a process should be like a lawyer's opening. Listen to the state's attorney: "We shall show, gentlemen of the jury, that A was foully murdered. We shall show, from physical signs attested by experts of the highest repute, that death must have occurred between the hours of 4:30 and 5:30 in the afternoon of a given day. We shall show, on the testimony of unimpeachable witnesses, first, that B was seen to enter and to leave the house within this time, and, on the evidence of the same witnesses, that no other persons within the same time either came or went. Finally, we shall show that in B's mind there existed hatred of long standing toward A, offering a sufficient motive to account for a deed of violence; and then we shall ask you, fair-minded gentlemen, in the light of such evidence, whether any other solution of the problem can possibly be found than that which involves the guilt of B."

Now let us take a mathematical case. "We wish to show that if the $f(x)$ represents a continuous function of x; and if, further, a and b are two numbers such that the $f(a)$ is plus, and the $f(b)$ is minus: then between a and b there lies some other number, c, such that the $f(c)$ equals zero. We shall show first that by halving the interval from a to b, and then halving the subintervals corresponding always to values of the functions with opposite signs, we obtain two series of values of the given function, each of which approaches a limit. We shall then show that these limits are identical. From the continuity of the function it will follow that this common limit will actually be attained. We shall show finally that this limit cannot be negative and that it cannot be positive. We shall then ask the fair-minded gentlemen before us whether any other solution is possible than that this will be zero."

Corresponding to the "physical signs" of the lawyer's plea, we have mathematical facts; the expert is, in the last analysis, the ordinary mind, and our witnesses are previous propositions, quite

as unimpeachable in their evidence as A's neighbors across the way. The student will thus be more vividly impressed with the fact, rarely emphasized in our teaching, and generally unrecognized by the average boy, that mathematical reasoning is merely the reasoning of everyday life put into symbols.

What we owe our pupils first of all is not so much a knowledge of facts as discipline in method. "To achieve the mastery of one's mental processes is," to quote from President Garfield's inaugural, "the chief end of an education," and the day is far distant when mathematics can be spared from the list of those subjects which make directly for this mastery. Clear, clean-cut thought, the power of sustained reasoning, is an essential for any man, whatever his calling, and this our science if properly taught can peculiarly foster.

Here let me suggest something that is absolutely fundamental, if a teacher hopes to arouse interest. He must have a boundless enthusiasm for his subject and his work. Interest is contagious. Years ago a young college graduate came back to teach physics in his alma mater. He was fresh from three years of study in Germany, mainly under Helmholz. Familiar with the subject in all its details, and having worked on its frontier, knowing its latest developments, he overestimated the capacity of his pupils—a common failure with young, thoroughly-trained scholars, and a serious fault, which in later years he corrected. But as one of his old pupils told me, at the very beginning the men hung on his words, strained to comprehend him, caught his enthusiasm, and left his lecture room with an ever-deepening interest in laws of physics.

A teacher must be unflagging to keep this enthusiasm on his own part alive. Not a little of his success will depend on his physical condition. There are many demands upon his time in the details of his daily work, but all this should be subordinated to freshness and elasticity of mind and body in the class room. And here let me say a word on the question of the correction of the written work. Such work is, on the part of the pupil, of high value and a certain amount of insistence upon it goes with successful teaching. But if at any time the burden of it is endangering the physical vigor which the hour of recitation has the right to demand, such work should be cut in two or stopped. I should emphasize this again and again, if I were in authority as the head of an institution.

A second and further help in developing interest on the part

of a teacher is an appreciation of the significance of his subject. Mathematics is the patriarch of sciences. It existed as a science when Abraham went down into Egypt, as we know from records recently discovered. Physics can hardly be said to date back farther than Plato; chemistry is a creature of the last two centuries, and biology was born less than a hundred years ago. Moreover, the history of mathematics has been distinguished by a steady advance. Other sciences have grown largely by a process of self-destruction: phœnix-like they have arisen from their own ashes. The corpuscular theory of light, championed by Newton and armed with all his prestige, had to give way before the undulatory theory of Young, and this in turn may have to yield before the modern theory of electrons. The old separate-creation theory in biology has been superseded by evolution. But the movement in mathematics has been like the flow of a great river, moving slowly at times, but ever steadily onward. There have been epochs in the history of science when by the discovery of some new method, some great tool, mathematicians have been frightened as to the foundations of some of their great theorems. But investigation in the light of all that is new, while it may have required a restatement, has left these theorems substantially undisturbed. But not merely in its history, but in the wonderful unity of its substance is our science unique and great. It was Kronecker, if I remember aright, who defined mathematics as the science of positive integers; he might well have said, signless integers. In a way, these are the only absolutely necessary data of mathematics. Taking them as given the mathematician begins his creation of artificial number; he inserts his fractions, extends his system by the creation of negatives, gives it continuity by the construction of irrationals; and then by number-pairs and number-triples creates his multiple algebras. But not satisfied with a unity that is contained in the realm of number, he reaches out into space, and establishes a one to one correspondence between the points of a line and the elements of his enlarged number system. In this way he harnesses geometry to analysis, and establishes an absolute unity in the whole realm of mathematical truth. As we go on with our teaching, we should have an ever-livelier sense of the dignity and essential greatness of the subject with which we are dealing.

Now at the close, some of you will pertinently inquire: Do you yourself follow out the suggestions which you have made? Frankly, no. It is notorious that pulpit orators do not practice

what they preach, or doctors take their own physic. Kuno Fischer used to narrate with great zest how Schopenhauer, the arch pessimist, who proved to his own satisfaction that this was about the worst world that could be conceived of—how this same Schopenhauer was an epicure of epicures, and lived a life of singular luxury. No, I don't do it; but I wish I did. I hold the ideals before me and strive toward them. Every now and then a teacher should examine himself, and see whither he is drifting; and then he should consult his charts. This means that he should have a chart, which is in fact a bundle of ideals, something at which to aim, a norm by which to regulate his life. What I have given you is my own chart. Each one of you has probably one of his own, one which shows rocks that do not appear on mine, and indicates favorable currents which I have not noted. But if I have succeeded in indicating any rocks or any currents, the knowledge of which will make your course more sure, I shall be satisfied.

TEXT-BOOK ENGLISH.

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A contributor to Science recently called attention to the philosophy in modern high school chemistries. Mine is the much less ambitious undertaking of showing some of their weak points. It has been my good fortune, or misfortune, to read a number of text-books and they left a bad taste in my mind. One pardons grammatical slips, minor misstatements, and errors of fact in papers and magazines as they must be hurriedly written, put into type and printed, and yet glaring errors are very rare there; but in text-books where no incorrect form should be seen; which are supposed to be written and rewritten; where the publisher takes his own time—and much of yours—to get them into type and off the press, they are as thick as the leaves in Vallombrosa. Some of them are due to careless proof-reading; some are errors which show distressing lack of training in the use of ordinary good English; while statements of fact—I should say *mis*statements—are too painfully evident. Surely teachers and those who prepare books for them should not be sinners in either respect, yet it is of these that I am to speak.

To classify as far as possible it may be well to begin with the adverb. It should be put as far away from the part of speech it qualifies as possible. If that does not make the meaning sufficiently un-clear arrange the sentence so as to bring about the greatest degree of ambiguity possible. "All do not contain the same number of atoms" (Not all etc.) "The energy possessed by coal only becomes available if the coal is made to undergo a chemical change." (Becomes available only if, etc.) "When we desire to merely show the weights taking part in a reaction." "Magnesium will only act rapidly if the water is hot." "By determining the gas density it is only possible to fix the molecular weight which exists in the gaseous condition." Does it mean "Only by determining the gas density is it possible to fix the molecular weight"? or perhaps "By determining the gas density it is possible to fix only the molecular weight—leaving the atomic weight still undetermined"? "Titanium dioxid is only dissolved by hydrofluoric acid." The fact is that titanium dioxid reacts with the acid and forms fluotitanic acid which contains no oxygen. "Aluminates are not very stable and are even decomposed by carbon dioxid." (Decomposed even by, etc.) But you can find plenty of such examples in almost any text-book you pick up.

The preposition is entirely too much for the average book-maker. "Different *than*"—(Different *then* in one case which we will charitably call a misprint), "At such conditions," "At standard conditions"—meaning "under," "Hydroxylamin in distinction *to* ammonia." "Water decomposes sodium peroxid *with* caustic soda and oxygen which escapes upon boiling." Of course water decomposes sodium peroxid with formation of caustic soda and liberation of oxygen which may be driven off by boiling but why did he take time to muddle up the statement?

Further, the writers cannot get away from the conglomerations of active participles linked to past participles. Being burned, being poured, being taken, being regenerated, being constantly altered, are examples. Each means, if it means anything, the continuation of a completed action. In most cases the context indicates a continuing action and that is correctly expressed by such words as while, or during. The antiquated mock-English *an* comes in repeatedly; "An halogen salt," "an Hg salt," an hydrogen compound, an hypothesis, an hundred, an history, an hydrate—which the student not always clear in his mind confuses with anhydrid—shall we finally have an house and an hat? That

might do if applied to the headgear now worn by some women but we may at least hope for a change in styles.

Agreement between subject and verb, order of words in the sentence, and so on call for attention. "None of the four substances are insoluble when water is present to hold them in solution," "When a series of sparks are passed, (Is the article *a* ever plural?) "The presence of what ions is shown by this test?" (What ions are shown, etc). "Sulphur or ores containing S (More about that "S" later) are burned in air." "Between each tier!" (He would have said between each *two* tiers if you had cornered him). We will all agree that *super* means over or above and that super-heated, for example, is a correct form when we mean to say that a body of gas, for instance, has its temperature raised above the normal, but why should we say super-cooled, or even highly cooled as one author puts it? To be sure we do find on rare occasions, under-cooled and that helps to restore our mental equilibrium. "It conducts heat and electricity better than all other gases"—meaning better than any other gas. "The heat capacity of water is greater than that of all other liquid or solid bodies—better than any other liquid or solid." "The boiling point of H_2SO_4 (of which more anon) is higher than that of any common body" (any other common body), "Two glass tubes fitting into one another" (How could each fit into the other?), "If we place two liquids above one another," are examples. Some of these writers seem to be imbued with the idea that the word *mixture* must always be preceded by the word *mechanical* and that the student will not get the idea of a compound unless it is labeled *chemical*. In chemistry mixtures are always mechanical and compounds are always chemical. Do we need speak of hydrocarbon acetylene or carbohydrate sugar? Further "metallic" means *elemental* to most of these people. Metallic silver, metallic Hg, metallic sodium, metallic Na, metallic Cu, metallic calcium, *red* metallic copper, metallic tin is a white metal, metallic phosphorus, metallic selenium, metallic silicon. I have not yet found metallic nitrogen or fluorin but they may come later. An element is either a metal or it is not. If it is, then the adjective is useless; if it is not, then the adjective makes the statement untrue. You may take your choice. Further, the so-called bases, are likewise metals, "Antimony acts like a metal," "Arsenic is sometimes a metal." "Ammonium is a metal," "The distinctive component of bases is a metal." If these expressions were used only to distinguish between different bases there would be no objection to

such forms but unfortunately these men cannot claim such a use; the context shows clearly that they have no such idea. No chemist of to-day needs be told that the distinctive part of a base is a hydroxyl group, and that the "metal" plays no part in its action —and the student has a right to demand accuracy of statement in the book put into his hands.

Hydrates are spoken of as "chemical" compounds or even as chemical substances which contain more or less water—(they never speak of sugar as containing water)—which is in part loosely combined—(Water of Crystallization)—and in part more firmly held—(Water of constitution). Some of these effloresce and become "anhydrous"—meaning dehydrated—and others deliquesce and form solutions, but you will look in vain for an explanation of either phenomenon. Of course, the student confuses anhydrous with anhydrid and small blame to him. If all such crystalline bodies were called hydrates and the words hydrated and dehydrated were properly employed all would be clear and we should have no difficulty in presenting the idea of chlorin hydrate, monohydrated sulphuric acid, carbohydrates, etc. A careful reading of the paragraphs on the behavior of hydrated copper sulphate in Alexander Smith's General Chemistry will clear up the whole matter for the teacher and then his students will have no trouble. Don't charge me with too much desire for the new. Gray's Chemistry (Andover, 1840) says water enters into many salts in whose crystallization it is taken up and in which it is therefore called water of crystallization, adding, "the definite compounds are called 'hydrates.'" Johnson's Chemistry (Philadelphia, 1867) does not use the expression "water of crystallization" at all. It reads, "water is capable of combining in definite proportion with many substances forming compounds which yet remain perfectly dry. They are usually called hydrates. Sulphids appear to have been looked upon as substances whose properties had been modified by the sulphur. They were spoken of as being sulphuretted—much as we use the word sweetened. Sulphuretted hydrogen and sweetened coffee were similar terms for similar modifications of properties. Then came phosphoretted, arseniuretted and antimoniuretted. With the exception of the first the others are rarely found. How long will it take us to drop that one and get rid of the antiquated name and the misleading assumptions and ideas that go with it! Hydrogen suphid carries no such burden.

It goes without saying that one should find accuracy of statement in a scientific book put into the hands of beginning students. Yet he may occasionally be disappointed. When iron burns in oxygen the intense heat fuses the oxid formed, yet three widely used texts speak of "globules of red-hot iron," of particles of red-hot metal, and of drops of molten iron. We are told that steam can be seen, that newspapers are printed from electrotype plates, that nitrogen peroxid dissolves in water—with an equation showing how it reacts with water—that it is not produced at first but is a product of secondary action with *air;* that sulphurous oxid *gas* has a strong odor, that sulphuric dioxid has a penetrating odor, while carbon monoxid has none; that nitric oxid has a strong and poisonous odor, or an extremely suffocating one; that HNO_3 dissolves lead, forming $Pb(NO_3)_2$, that AgCl dissolves in NH_4OH, that there are oceans of "burning" hydrogen in the sun, that a metal rod *lengthens*—too much work to say expands, I suppose—that stearic, margaric and palmitic acids are very "useful" in fats, that "atmospheric" air is composed of O and N, that water is a constituent of almost every form of animal and vegetable organism; that CO_2 is not poisonous unless present in large quantities, the idea still being that carbon dioxid is a poison, that O unites with all other elements except F, that H_2SO_4 is stronger than HNO_3 and displaces it from its compound, that perfectly dry chlorin makes antimony burn brilliantly, that gypsum deprived of its water by calcination forms plaster of paris, or when gypsum loses all its water it becomes burnt gypsum, that the bullet which *in its flight is sustained by resistance* becomes hot (I should think it would), that alcoholic salts—methyl chlorid, propyl nitrate, amyl sulphate, etc., are called ethers, that natural fats are simply ethers corresponding to glycerin. They talk of the influence of mass and of mass action when they mean concentration, they speak of laws which govern and of gases which no longer obey the law, (the last edition of Encyclopedia Britannica asks: What are the laws which govern the action of these forces) and the last text I looked through says: We now know that compounds of carbon, whatever their source, are subject to the laws that govern all other compounds, that Avogadro's hypothesis postulates equal numbers of atoms in equal volumes under like conditions, that a heavy gas delivered at the bottom of a receiver driving the lighter air upward is collected by downward displacement of air, and, conversely, that a light gas col-

lected in the upper part of an inverted receiver is collected by upward displacement of air; that a gas collected over water rises and forces the water down, that nitrogen tetroxid is hyponitric acid, that there are calories of heat and degrees of cold—one old text says degrees of frost.

Some of these writers have yet to learn that they live in an atmosphere such as ours is, or at least, that the atmosphere exerts pressure. They *draw* air into their lungs, the current of gas in a Bunsen burner *draws* air through the holes, an aspirator *draws* air through the apparatus; when the flame is taken from a generator the water sucks back and there is a suction in the receiver of the air-pump. What possible chance for the student to get clear ideas and do clear thinking when his teachers talk that way?

They speak of atoms and radicals as they would of the letters in a word. The two hydrogens in H_2SO_4 (Aitch two ess oh four); the three hydroxyls in $B(OH)_3$; the nitrogens in ammonium nitrate are exactly on a par with the two esses in miss. Likewise we have the iodins in HgI_2 and the oxygens in BaO_2. Are we coming to a time when we shall speak of the sodiums (or will they be sodas?), the sulphurs and the oxygens in hypo? The directions given the student are amazing or amusing. He is told to blow out a splinter or a match or a candle or a lighted candle, to turn a flame up or down, to use unheard-of amounts of reagents. I quote but one: Add 10 cubic centimeters concentrated nitric acid to a hot solution of ferrous sulphate and boil. Test a portion for a ferric salt. Ten cubic centimeters of nitric acid contain 9.6 grams of acid. If three atoms of oxygen from two molecules of the acid change six molecules of ferrous sulphate to three molecules of the ferric salt, then 9.6 grams of nitric acid would oxidize 60.6 grams of ferrous salt to the higher valence. Using the concentration recommended by the author of this particular book this would make about seven liters of the ferrous sulphate solution. What size of test-tube or beaker does the student use?

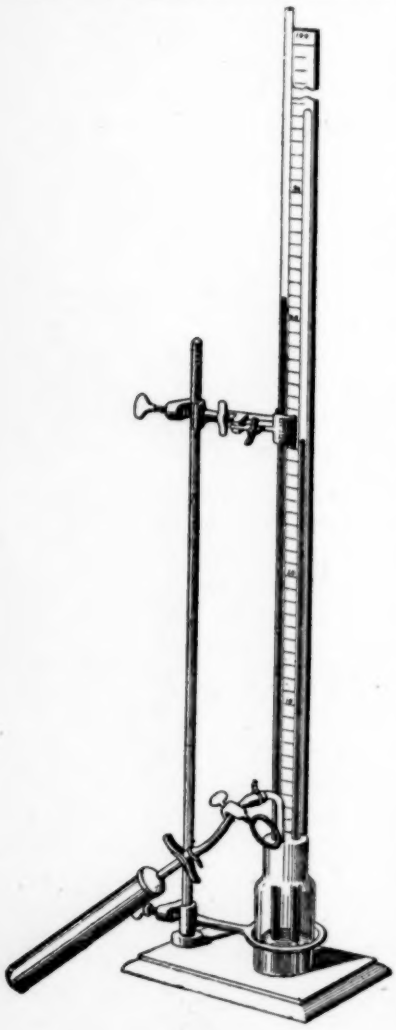
One more complaint and I am done. That is the spelling of symbols and formulae. I have written these as printed in a few cases and spelled one of them out in full but that does not seem to be enough. S indicates one atom of sulphur and is incorrectly used for any larger amount as grams or tons.[1]

[1]Mr. W. A. Puckner in Reports of the Chemical Laboratory of the American Medical Association, Vol. 3, Jan.-Dec., 1910, has something apropos to this discussion.

AN APPARATUS FOR BOTH BOYLE'S AND CHARLES'S LAW.

By C. E. Linebarger,
Lake View High School, Chicago, Ill.

The apparatus consists of an open and a closed manometer, both straight and vertical, and made of glass of ordinary size, with their lower ends dipping into mercury contained in a vessel connected with an air compressor. To vary the temperature of the air within the closed manometer, this may be surrounded by a jacketing tube (not shown in the figure) through which liquids at different temperatures or the vapors of boiling liquids, such as water, ether, acetne, carbon tetrachloride, alcohol, etc., may be passed.



The open manometer is about 110 cm. long and passes through one of the holes of a thrice perforated stopper. The closed manometer is about 60 cm. in length and passes through a second hole, while the third hole is provided with an L-tube. The lower ends of the manometers should be rotated in a flame until they fuse nearly together, leaving an opening about a millimeter in diameter; this will prevent undue surging of the mercury when forced up into the tubes. The upper end of the closed manometer should be as nearly flat as it is possible to make it so that no correction need be applied to the volume (actually measured as a length on the assumption that the bore of the tube is uniform) on account of the convexity of the end. It is well to have the upper end of the open ma-

nometer flared out like a funnel, or fitted with a cork over which is fixed a broken test tube, such an arrangement preventing the overflow of mercury, which may otherwise happen should the air in the vessel be compressed too rapidly.

The stopper is fitted to a screw cap bottle, and a circle punched out of the cap just large enough to accommodate the three tubes. To fill the closed manometer with dry air, connect it with a chloride of calcium tube and pass a Bunsen flame along it until its entire length is heated nearly to redness. Let it cool to the temperature of the room, disconnect from the drying tube, and, before any considerable amount of the dried air can escape, dip the open end of the tube into vaseline. The short plug of vaseline that will enter the tube effectually seals the dried air unless it is heated too much by handling.

Fill the bottle to a depth of about three centimeters with clean and dry mercury, cover the mercury with a thick layer of calcium chloride[1], insert the stopper into the neck of the bottle, and push the ends of the manometers down nearly to the bottom. Screw on the cap and, connecting a bicycle valve and pump to the L-tube by means of rubber tubing, pump air into the bottle until the stopper is forced up snugly against the cap. It may be found necessary to bind the rubber tubing by wire or string both to the L-tube and to the bicycle valve.

Remove the bicycle valve and pump and substitute an exhaust pump. Close the upper end of the open tube with a tiny lump of beeswax. Exhaust the air in the bottle a little, and then disconnect; the mercury will rise in the tubes. Continue the exhaustion by degrees until the mercury rises to a distance above the stopper equal to about a fourth of the length of the closed manometer. Replace the rubber tubing connecting the L-tube to the bicycle valve, interposing a screw cock and binding the rubber tubing to the valve and L-tube.

The jacketing tube is a piece of wide and thin glass tubing with its ends flared a little for the reception of stoppers, and is a little longer than the portion of the closed manometer extending above the screw cap. Its ends are closed with two-hole stoppers, one hole of each of which is fitted with an L-tube, while the closed manometer is thrust through the other hole of the lower stopper, and a thermometer through the remaining hole of the upper stopper.

[1]To prepare perfectly dry calcium chloride in thin cakes or plates, proceed as follows: Heat a lump of the chloride held by crucible tongs in a large blast flame. The chloride will fuse and the drops that fall from the lump are caught upon a plate or a piece of sheet metal.

The apparatus may be supported on a retort stand, one ring encircling the bottle and a smaller ring or a burette clamp near the top of the rod holding the tubes. Special metal stands are also made to hold the apparatus. A meter stick is secured alongside the tubes by a clamp or by means of cord or rubber bands, one end of it resting upon the screw cap.

The apparatus when assembled may be used season after season at a moment's notice except for the occasional replacing of the rubber tubing due to its deterioration and of the calcium chloride because of its deliquescence. The support, meter stick and pump can be detached, of course, and made available in other experiments. The principle of the operation of the apparatus is readily understood by students, its action is rapid and its results are reliable. A dozen pieces of the apparatus have been used in the writer's laboratory for several years, and have proved perfectly satisfactory both to pupils and instructor.

The apparatus is used (1) to find the relationship between the pressure and the volume of a mass of gas at constant temperature (Boyle's Law); (2) to determine the coefficient of expansion of a gas kept under constant pressure (volume coefficient of expansion); and (3) to find the coefficient of expansion of a gas maintained at a constant volume (pressure coefficient of expansion). It is also utilizable in demonstrating the principle of pressure transmission and of manometers. The manner of employing the apparatus for these purposes as well as the kind of results that may be obtained are considered in what follows.

Boyle's Law.

The apparatus is arranged as shown in the figure. The jacketing tube is hardly necessary, inasmuch as the temperature of the laboratory may usually be considered as remaining uniform during the brief time required for the performance of the experiment. Still it is but little trouble to run water from a large supply kept well stirred so as to maintain constancy of temperature up through the jacketing tube, or to pass steam from a boiler down through it. The data will then not be influenced by any variations in the temperature of the room.

The meter stick is read at a point on a level with the inner surface of the upper end of the closed tube. The pump is then worked until the mercury in the open tube is forced a little above that in the closed tube. Usually the apparatus leaks a little so that the mercury levels fall slowly. The rubber tubing

can be pinched together either with the screw cock or between the thumb and finger so that it is possible to prevent the movement of the mercury long enough to make a reading when it is at the same level in both tubes. If, however, the apparatus is tight, and the mercury remains stationary or falls too slowly, disconnect the pump, and open the valve by sticking a pencil point into it.

When the mercury stands at the same level in both tubes, the pressure of the confined air is equal to that of the atmosphere as read on a barometer. When the mercury in the open tube is higher than in the closed tube, the pressure on the confined air is greater than that of the atmosphere; and when it is lower, the air is under a pressure less than that of the atmosphere. The apparatus therefore permits of studying Boyle's Law at pressures both greater and less than atmospheric.

Air is now pumped into the bottle until mercury is forced up to nearly the top of the open tube. By pinching the rubber tubing, the mercury can be prevented from sinking, and readings of the mercury levels in both tubes are made. Two students can work to advantage here, one reading the mercury level in the open tube at the same instant that the other reads the mercury level in the closed tube. Enough air is allowed to escape from the bottle to let the mercury sink about ten centimeters in the open manometer. The motion of the mercury is then checked and readings of both levels taken. In similar fashion additional readings are taken until the mercury in the open tube sinks below the stopper.

The following tabulation taken from a student's notebook shows what results the apparatus can yield. It is not too much to require that the products of P and V do not differ by more than two per cent.

TABULATION FOR BOYLE'S LAW.

A. Barometer reading, 75.9 cm. **B.** Reading at top of closed tube, 82.0 cm.

C Readings on open tube	D Readings on closed tube	C−D Pressure above atmospheric	D−C Pressure below atmospheric	A+(C−D) Pressures P greater than atmospheric	A−(D−C) Pressures P less than atmospheric	B−D Volumes, V	P×V
75.5 cm.	52.8 cm.	22.7 cm.		96.5 cm.		27.3 cm.	264 × 10
66.8	50.7	16.1		89.9		29.4	264
60.4	48.9	11.5		85.3		31.2	266
49.5	45.9	3.6		77.4		34.2	265
42.1	43.5		1.4 cm.		72.4 cm.	36.6	265
37.0	41.7		4.7		69.1	38.4	265
31.4	39.7		8.3		65.5	40.4	262
27.8	38.3		10.5		63.3	41.8	264

Volume Coefficient of Expansion.

The temperature of the air within the closed manometer is reduced to 0° by running a weak salt or alcoholic solution through the jacketing tube, previously cooled to about —2° by putting plenty of snow or cracked ice into it. By regulating the speed of flow by means of a screw cock compressing the rubber tubing leading the solution to the jacketing tube, the temperature of the confined air can be maintained at 0°. Air is pumped into the bottle until the mercury stands at the same height in both manometers. The difference between the readings on the meter stick at points on a level (1) with the inner surface of the upper extremity of the closed tube and (2) with the mercury gives the volume of the air at 0°.

After the solution is run out of the jacketing tube, steam from a boiler is passed through it. The temperature of the imprisoned air is thereby raised to that of the boiling point of water under the prevailing pressure of the atmosphere. It is easy to increase the pressure of the steam by compressing the rubber tubing somewhat so that its temperature may be raised to 100°, but that is unnecessary for the purpose of this experiment. When enough air is pumped into the bottle to raise the mercury in both tubes to the same level, a reading on the meter stick is made. The difference between it and the reading at the top of the closed manometer gives the volume at the higher temperature. From these data the volume coefficient may be computed as shown in the annexed tabulation. Determinations usually give values differing by less than three per cent from the accepted value of .00367[2].

Pressure Coefficient of Expansion.

While the steam is still being passed through the apparatus, the pump is worked until the mercury in the closed tube is forced up to the same level that it occupied when the volume of the enclosed air was read at 0° and under atmospheric pressure. The level of the mercury in the open tube is read at the same time, and the increase of pressure needed to keep the air at a constant volume ascertained. The pressure coefficient is calculated as shown in the tabulation.

Tabulation for Charles's Law.

		1st trial	2nd trial
A.	Barometer reading	74.5 cm.	74.5 cm.
B.	Reading at the top of the air column	67.6 cm.	67.6 cm.

[2]Students' directions for performing the experiments with this apparatus are given in the writer's Laboratory Manual of Physics (D. C. Heath & Co.)

C.	Reading of the mercury level in both tubes when the air is at 0°	1st adjustment	42.4 cm.	42.3 cm.
		2nd "	42.3	42.4
		3rd "	42.3	42.3
		Average	42.3	42.3
t.	Temperature when steam is passed		99.4°	99.4°
D.	Reading of the mercury level in both tubes when the air is at $t°$	1st adjustment	33.4 cm.	33.3 cm.
		2nd "	33.3	33.3
		3rd "	33.4	33.3
		Average	33.4	33.3
E.	Reading on the open tube when the temperature of the air is $t°$ and the reading on the closed tube is the same as in *C*	1st adjustment	68.7 cm.	69.0 cm.
		2nd "	68.9	68.6
		3rd "	68.5	68.5
		Average	68.7	68.7
F.	Volume of the air at 0° and *A* cm. $[B - C]$		25.3 cm.	25.3 cm.
G.	Volume of the air at $t°$ and *A* cm. [B — D]		34.2 cm.	34.3 cm.
	Increase in volume under pressure of *A* cm. $[G - F]$		8.9 cm.	9.0 cm.
	Coefficient of expansion under constant pressure $\left[\frac{G-F}{Ft°}\right]$		.00355	.00361
	Per cent of error		3%	2%
H.	Pressure of the air with volume constant at $t°$ $[E - C + A]$		100.9 cm.	101.1 cm.
	Increase in pressure with constant volume $[E - C]$		26.4 cm.	26.5 cm.
	Coefficient of expansion with constant volume $\left[\frac{H-A}{At°}\right]$		.00356	.00357
	Per cent of error		3%	3%

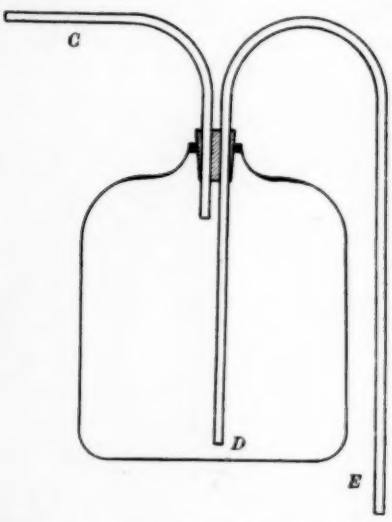
Good values for the expansion coefficients cannot be obtained unless the imprisoned air is kept perfectly dry. The common procedure of putting a drop of strong sulphuric acid within the tube cannot, of course, be employed with a vertical tube, and it has been pointed out that "sulphuric acid does not serve the purpose for which it is intended" (Hennings, this Journal, Vol. XII, p. 9). The experience of the writer has been similar to that of the authority just quoted. Freshly prepared closed manometers were found to give results with small error, but after standing for a year they yielded values for the coefficients that were much too large. The use of calcium chloride, however, relieved the situation satisfactorily. One closed manometer was made of tubing of about six millimeters bore, and a couple of tiny lumps of freshly fused calcium chloride introduced into

it so as to float upon the surface of the mercury within the tube. The volume of the chloride was regarded as negligible, and the apparatus has given excellent results for four seasons. The use of calcium chloride within the bottle prevents moisture from getting into the air within the closed tube. Since the outlet of the bottle is provided with a bicycle valve, one filling of the chloride lasts some time before it deliquesces enough to seriously impair its drying power.

A CONVENIENT GASOMETER.

By N. F. Smith.

Many interesting physical experiments—such, for example, as those with the sensitive flame—require for their execution a gas pressure in excess of that supplied by the ordinary city gas works. Since few elementary laboratories are supplied with gas tanks containing compressed hydrogen or coal gas, these instructive experiments are commonly omitted. For the performance of such experiments, the following extremely simple device has been found effective and convenient.



An empty carboy, gasoline can or other air-tight receptacle holding from three to five gallons is fitted with a two-hole rubber stopper through which pass a siphon, DE, and an inlet tube, C. The container is first filled with water, after which C is connected to the gas-cock and the water displaced by gas. C is then connected to the burner where gas at high pressure is desired. E is connected to the water tap and the faucet opened until the desired pressure is obtained. By regulating the rate at which water is supplied, any desired gas pressure can be secured. A five gallon container will supply gas for a sensitive flame for one or two hours without refilling.

A GENERAL SCIENCE COURSE OF ELEMENTARY PHYSICS AND MATHEMATICS COMBINED.

By J. C. Gray,
Thornton Academy, Saco, Maine.

Along with the other suggestions for a general science course which have appeared in this magazine the writer offers the following, believing that only by discussion and exchange of ideas can a general science course be developed such as will be generally accepted. His suggestion is for a course of elementary physics and mathematics combined, so that each subject will furnish material for the other, thus securing a suitable correlation of the science and mathematics, which will help the pupil in each. This course in general science is given in the second year, five times a week, following the first year algebra. It is followed in the third year by chemistry, and in the fourth year by physics for those going to college and by applied science for those not going. This course and this order of chemistry and physics has just been started at Thornton Academy, so it is yet too early to judge of the results.

Most science teachers now recognize the need of an introductory science course, but differ in what its content should be. Some believe that such a course should teach a little about every science which the pupil is likely to study in the high school: chemistry, physics, physical geography, botany, zoölogy, and even physiology; others that it should be based on physical geography or agriculture and journey into physics or chemistry for explanation of phenomena. But the chief objection to such courses in general science is that they just skim the surface of the subject without giving the pupil much of real educational value. To be of real benefit to the pupil an efficient general science course must develop his mental abilities, as well as give the elements on which to base further work in science. Both of these purposes can best be served by taking up in a thorough manner a few subjects in physics, which are to be most used later, with experiments, problems, explanations, and applications. The experiments teach the pupil how to measure and to weigh carefully and to record data in the notebook, as well as furnishing material for the problem work. The problems, if carefully chosen, give the opportunity to apply algebra and geometry, the uses of which in science always trouble pupils. The explanations and applications of the subjects studied give the fundamental facts to be used in further science study.

Aside from the general objects of high school science courses as usually stated, namely, (1) to develop the pupil's powers of observation and of reasoning, (2) to train him in methods of scientific work and expression, and (3) to extend his knowledge of scientific subjects, this general science course may be said to have for its specific objects (1) to lay a firm foundation for further work in science and (2) to help the pupil who finds mathematics hard.

In attempting to carry out the first of these objects, to lay a firm foundation for further work in science, such topics in physics are taken up as are most useful for work in chemistry the next year, or as furnish good problems for applications of mathematics. Some of these topics are the metric system, measuring and weighing, density, specific gravity, measurement of temperature and of pressure, Charles' and Boyle's Laws, states of matter, melting and boiling points, Ohm's Law, polarity, etc.

In attempting to carry out the second of these objects, to help the pupil who finds mathematics hard, the work is not taken up in any logical order, but algebra and geometry are brought in as they are needed in the work in physics; that is, the pupil finds some need for algebra or geometry in working out some problem, before he is given the mathematical principle to use. Mathematics is regarded chiefly as a tool to be used in the study of science; hence those subjects are taken up, which are useful in science. Speed, accuracy, and quick methods of solving are drilled on, rather than the more difficult and less useful principles. In algebra, the work of the first year, through fractional equations is reviewed, because many of the pupils taking this course have had trouble with their first year algebra; then involution, evolution, and simultaneous equations are considered, and also a little work with surds and exponents. In geometry lines, angles, triangles, circles, quadrilaterals, constructions, plotting curves, and proportion are taken up. With all these mathematical subjects some problem in science is first given, for the solution of which the mathematics is required.

Each subject in science is brought up by means of experiments, either by the pupils or by the teacher, which illustrate the principle in physics to be studied and gives a basis on which to work. In applying the principle the need of some subject in algebra or geometry is realized, which subject is then given and applied at once on the problem at hand.

An example will best show how the work in physics and mathe-

matics can be combined in experiments and problems. On the first day about a dozen different objects, such as balances, motors, galvanometers, lenses, and various other pieces of apparatus, were placed on the tables. The pupils were told to look around for five minutes and then describe the three most interesting things they saw. Among the objects were two jars, one of water and the other of mercury, each containing an iron weight. About two thirds of the class noted the iron weight floating on the mercury as one of their three most interesting objects, so we started in to find the explanation. A little questioning brought out the need of being able to weigh and to measure the water and the mercury, which led to the metric system. After this, the subject of density was studied, being preceded by suitable experiments and being brought up by the consideration of the weight of a cubic centimeter of other substances than water. Working density problems, using the formula, brought in the need of algebra in the solution of fractional equations, so this subject was taken up in algebra, after first reviewing the subjects usually coming before fractional equations. Then followed specific gravity and the relation between the loss in weight of a body in a liquid and the weight of the liquid displaced, which explained the floating of the iron in the mercury.

Similarly, the length of object and of image formed by a lens or Charles' Law can be used for applications of a direct ratio; Boyle's Law for an inverse ratio; the inclined plane and heights of objects and lengths of shadows for similar triangles, which bring in the finding of the third side of a triangle when the other two are given, which in turn brings in involution and evolution. Similar triangles, of course, bring in also the direct ratio. These suffice to suggest some of the ways in which physics and mathematics may be correlated, the science subjects being grouped according to the mathematical principles which are used in solving them.

Some may object to a general science course like this, because it is planned for the second year, believing it ought to be in the first year. However, it would be perfectly possible to have such a course in the first year along with the first year algebra; that is, two separate courses, as there would not be time in one course to cover all the elements of algebra and the science besides. The two courses could be worked together, especially if the same teacher had both.

Another objection will come from those who plan a general science course in order that the pupil who leaves school in the first or second year may get some acquaintance with scientific facts. Instead of planning the course for the benefit of just such a pupil, why not plan to prevent his leaving school? This can be done in one way by helping him in his mathematics, letting him pass off a condition in first year algebra by taking a course of science and mathematics combined. If the real causes of so many pupils becoming discouraged and leaving school could be known, trouble with mathematics, I venture, would be found to be one of the most common. A course of elementary physics and mathematics combined would be well worth while, if it would save some, if not all, of these pupils for the school.

CRYSTALLIZATION.

By Franklin T. Jones,
University School, Cleveland.

The growth of crystals is a fascinating thing to watch. Usually the operation is, of necessity, carried on upon such a small scale that only one or two students can observe it at a time and, besides, to get good crystals, the growth is too slow to watch without great loss of time. It is possible to perform this experiment very simply and to show it to a whole class at a time at any place where a stereopticon is available.

Make a saturated hot solution of common salt, or of any substance whose crystals it is desired to observe. Place a drop or two on a clean glass plate, warm the plate slightly and place it either in front of the condensers as though it were a slide, or, better, place it on the stage of the vertical projector. Evaporation will take place very rapidly and the crystals will form by the time the teacher can explain what he intends to show.

Exceptionally beautiful effects are formed in sodium chloride solution. The cubical form of the crystals, the step construction, growth from the inside outward, dispersion effects showing colors, bright diagonals due to dispersion probably, etc., are all shown within a few minutes. The pattern is changing continually so there is no opportunity for a moment's lack of interest.

The experiment described is not new but the writer has not seen it previously explained in the columns of School Science and Mathematics.

INSPECTION OF CHEMICAL INDUSTRIES BY STUDENTS IN THE SECONDARY SCHOOLS.[1]

By C. A. Vallance,
Manual Training High School, Indianapolis.

The present era is one of unrest. A period of a few years has witnessed great changes in all phases of life. Industrial processes, religious thought, and educational methods and institutions have all been more or less affected during this time. Twenty years ago in the educational world the academy was still flourishing and the normal school was preparing students for the college and the university, as well as giving training in teaching. Within this period the high school has grown rapidly usurping entirely the position of the academy. It has made the preparatory work of the normal school of secondary importance, and to-day, in the teaching of many branches, is a competitor with the small college. As a result of such rapid growth the curriculum of the high school has undergone radical changes not only in the nature of the subjects taught but also in the subject-matter and the method of presenting it. In the adjustment of the course more importance is being given to the natural sciences, though not without opposition on the part of teachers and friends of subjects of traditional importance. Progressive educators, however, realize that no boy or girl should leave the high school without at least a rudimentary knowledge of some of those materials and processes upon which the life and health of the individual and the welfare of the community depend.

The general tendency in all of these changes is to make the school articulate with daily life and no subject offers better opportunities for this than chemistry. The various laboratory experiments dealing with materials and processes common to daily life, views of manufacturing plants, samples of material used in various industries, and visits to the plants themselves are all effective methods for accomplishing this.

Inspection of chemical industries by classes in technology has been followed for a long time by universities and technical schools. Their aim, however, is to give a technical training instead of a general understanding of the work as should be the case in the secondary school.

The industries to be visited by a high school class must be

[1] Read before the Chemical Section of the C. A. S. & M. T. at Lewis Institute, Chicago Dec. 1, 1911.

largely local for time and expense prevent going to any distance. Although greater opportunities are offered to students of the larger cities since the industries are so varied, yet in nearly all of the smaller places there are generally some plants that can be visited with profit. It may be only a bakery, a cannery, or some other industry that to the pupil may appear to have no relation to chemistry.

Many secondary teachers have but little interest in the industrial side of the work because they have had no training in technical chemistry. In order to have a broad comprehension of his subject the teacher should understand not only the theoretical side of the work but also many of the common industries involving chemical processes. This is the phase of the subject that appeals most strongly to the boys and girls, and nothing will make the course and the teacher more popular than work along this line. Supplementary to a good training, the progressive chemistry teacher should keep fairly well informed in regard to the industrial side of his subject by means of a good magazine of industrial chemistry.

It is unnecessary to say that before visiting a plant arrangements should be made with the manager or superintendent. In some cases visitors are not allowed either on account of secret processes or machinery, or because of the inconvenience. Permission is generally given willingly in case of those industries that depend upon the public for the disposal of their product or for their franchise. Especially is this true of gas works, water works, plants for garbage disposal, bakeries, etc. It is a good way of cheap advertising for in this way they obtain the good will of boys and girls soon to become the heads of families and as citizens, to have a voice in determining the relations of these industries to the municipality.

As a rule, much better results will be obtained if the teacher visits the plant first and becomes acquainted with the superintendent or chemist. This will make the teacher more efficient for it will take him away from books and the routine of school, and will give him a broader view of his subject by bringing him in contact with the business man and his work. On the other hand, the business man will have a better idea of the teacher and the work of the high school and will not be so opposed to paying taxes to support an institution which too often he believes gives a training of but little value to the boy.

The success of a teacher in this line of work depends largely

upon whether he himself understands the processes and the various mechanical appliances in the plant to be visited and can explain them to the class. On one occasion I visited a power plant with a teacher of physics and his class. He had to depend upon some of the students to find the way to the place, was not acquainted with the superintendent and knew but very little about the plant itself. Although a conscientious teacher and capable in many ways, the lack of technical training and his method of making the visit made it of little value.

In preparation for such an inspection the student should first obtain a fairly good understanding of the industry from textbooks and from explanations by the teacher. The best results will be obtained if the teacher confines the description largely to the individual plant to be visited and to the process employed. An explanation that is too technical or that enters too fully into detail should be avoided for the object of the work is general rather than to make glass chemists or superintendents of gas plants. Lantern slides showing the various parts of the plant and the machinery will help the pupil to understand what he sees during the visit. The teacher should have also samples of the raw material and the finished product to show the class. Such preparation as this is necessary if the student is to profit by the trip for even skilled chemists when visiting an extensive plant in a large party do not understand much of the work, and on account of the noise, are unable to hear the explanations that are made.

After inspecting the plant the student should be required to write a composition on the subject explaining the process by any necessary drawings. These compositions should be made a part of the laboratory record book. Often it is a good plan for the teacher to prepare an outline of the work such as is here suggested in connection with a visit to a fertilizer plant.

I. Constituents of Plants.
   a. Nitrogen. Forms of nitrogenous foods.
   b. Potash.
   c. Phosphorus.
   d. Carbon, silica, sulphur, etc.

II. Forms and Sources.
   a. Nitrogen.
      1. Soluble nitrates, Chili saltpetre or nitre.
      2. Ammonia compounds, especially $(NH_4)_2SO_4$.
      3. Organic compounds.
         a. Garbage. Treatment and by-products.

b. Dead animals.
c. Manures.
d. Packing house by-products. Blood, tankage.

4. Nitrogen from the air.
   a. Electrical process.
   b. Cyanamide.
   c. Nitrifying bacteria.

b. Potash.
   1. Soluble potash salts.
      a. KCl—Kanit from Germany.
      b. K_2SO_4—also from Germany.
      c. K_2CO_3—wood ashes.
   2. Decomposition of rocks.

c. Phosphorus.
   1. Parts of plants and animals needing phosphates.
   2. Insoluble phosphate rock.
      a. Deposits in Florida, Carolinas, etc.
         Discuss conservation of deposits and need of an export tax.
      b. Conversion by H_2SO_4.
      c. Conversion in nature.
      d. Bone ash.

As a rule, the plant should be inspected as soon as the pupils have completed the subject as taken up in their text-books. In some cases such as the manufacture of sulphuric acid, it is better to wait until they have had the work on nitrogen and phosphorus in order that they may visit the fertilizer plant at the same time. If only local industries are to be visited the class can make the trip on a Saturday or at the close of school. A very good arrangement is to have the chemistry period the last in the afternoon so that this time can then be used and attendance can be required. However, if the teacher is enthusiastic and the subject has been taken up in the right way, the majority of the students will be eager to go at any time and will remember this part of the work long after theories and formulas are forgotten.

In order to understand very well such industries as the manufacture of starch, glucose, soap-making, brewing, distilling, oil refining, etc., it will be necessary to give a little organic chemistry. Many high schools omit this work entirely and instead devote a month or more to qualitative analysis. This seems to me to be a great mistake. The subject-matter in the high school

should be such as will give the best mental training together with a knowledge of the materials and processes commonly occurring in daily life. Analytical reactions and the properties of substances as learned from these reactions will be of little value to the student who does not pursue the subject of chemistry farther. And in the university no credit is given for this work, so the student must cover the same ground twice. On the other hand if this time were devoted to a brief consideration of organic chemistry, our students would understand better some of the common things and changes of their daily life such as fermentation, the formation of vinegar, the petroleum industry, coal tar and its simple derivatives, wood alcohol, denatured alcohol, etc. Few of our students will be more efficient citizens for knowing how to separate the chlorides of lead, silver, and mercury, or the color of this, that, and the other sulphid, but whether he is a live citizen or a dead one will depend upon his starting the fire with gasoline, or drinking wood alcohol, or as a farmer going into his cellar with a candle to inspect his acetylene generator. Nearly every day one reads of explosions, fires, deaths and other accidents in handling these things.

By visiting various factories the student will have a much better idea of the industries of his own city. It is remarkable how many people in a large place are ignorant of the industries carried on in their own community. Comparatively few people in Indianapolis know that there is a fertilizer works in the city and that it disposes of all the garbage, or that the greater part of the milk and beer bottles are made by a local concern. The more a pupil knows about these industries, the more civic pride he will have and the better citizen he will become.

With the increasing complexity of our social, our political and our industrial life the greater is their interrelation and interdependence. A generation ago the garbage was cared for by the family pig, the ashes filled the mudholes and made the walks, and the sewage went to the land as fertilizer. To-day we must depend upon some department of our municipal government or upon a private company to perform these functions. Many people in the city do not know that refuse will be taken away free, and consequently they decorate the alleys and vacant lots with tin cans and ash heaps. In many of our cities graft and corruption are carried on openly in these departments and by these companies. The city often enters into a one-sided contract or maintains an inefficient system because of ignorance

and lack of interest. In Indianapolis our council is trying to decide whether to increase the contract price with a private company for disposing of the garbage or whether to erect a municipal plant. Our chemistry students since visiting the fertilizer works and realizing the value of the garbage, are manifesting much interest in the question and could perhaps vote on it as intelligently and honestly as some of our councilmen.

One of the greatest problems confronting our industrial world to-day is the conservation of our resources. The technically trained man realizes better than anyone else the great waste that occurs in many branches of the industrial world. Much of this waste is the result of following traditional methods. The road to conservation would be much easier if the manufacturer had such general training as would enable him to realize the value of expert advice in buying bricks either of gold or clay, and the need of technically trained men as superintendents and managers. We should teach the boy of to-day the necessity of conservation and how it may be accomplished so that as the manufacturer of to-morrow he will voluntarily look to the scientist and technical man to make his plant more efficient.

These visits, too, will help the boy to find himself. During his high school life the boy should be planning his future. On the other hand we frequently find him leaving our institutions with no definite aim in life, with few ideas of what he can do or would like to do, and with no realization of the great opportunities in the various branches of industrial work. Often times the same is true of his college course and he spends time and money in preparing for work for which he is not fitted either physically or mentally. In order to help the boy in selecting his future work we should open his eyes to our industrial processes, point out to him the need of technically trained men, and show him how the welfare of the community is coming to depend more and more on the scientific management of our farms, our factories, and other branches of industry. Then will we find him making plans for the part he is to play in the industrial world.

And last but not least among the benefits to be derived from these visits is the establishing of more intimate relations between the student and the teacher. The great changes in our social and economic conditions have eliminated more or less from the child's life the influence of the home. The father is so occupied with his business affairs that he has no time to establish confi-

dential relations with his child. Under present economic conditions the mother too frequently is forced into the store or factory not only to provide for herself and family but also to enable a class of so-called mothers to spend time and money in promoting social functions and other forms of amusement characteristic of the idle rich. The effect in either case is the same as far as the child is concerned, so that during the critical period of adolescence the responsibility for the child's physical and moral development as well as his mental falls on the teacher. And what do we too often find in our schools? A corps of men and women, specialists in everything except just plain boys and girls. The sciences, languages, mathematics, all taught by instructors who are required to show by examinations that they are qualified to teach these subjects, while the greatest subject of all, the adolescent child, is forgotten.

Before a boy or girl is allowed to perform a difficult or dangerous experiment in the laboratory, we explain carefully the reaction, show how it conforms to chemical laws, and then warn especially against the dangers. How different in the laboratory of life! Here we turn loose our boys and girls to perform experiments more dangerous than the preparation of a powerful explosive or the generation of a noxious gas, experiments that will result either in the most wonderful thing in the world, a man or a woman made in the image of God, or in such human wreckage as fills our hospitals and penal institutions. And how is the child prepared? Not a word of warning as to these dangers, no explicit directions, and no parent or teacher intimate enough with the child to offer this information or from whom the child will voluntarily seek this information.

To the instructor in chemistry these trips offer an exceptional opportunity to break down the restraint and reserve that too frequently separate pupil and teacher. This will enable the teacher before the end of the course to discuss with the class the sexual question, to tell them about the nature and consequences of venereal diseases, information too often learned in the bitter school of experience, and to show them the necessity of learning early in life the power of self-control. The teacher who has the spirit to do this is inspired by the great Teacher of all ages.

GLUE FOR GLUING LEATHER ARTICLES.—To ordinary glue, some alum is added. The glue thereby not only acquires greater capacity for resisting the effects of moisture, but becomes flexible and is consequently better adapted for gluing saddlery goods, straps, etc.—*Ledertech. Rundschau.*

WHAT SHALL THE SECOND TERM'S WORK IN HIGH SCHOOL GEOGRAPHY BE?[1]

By R. H. Whitbeck,
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Editor of the Journal of Geography.

For some four or five years past, it has been evident that a change must be made in high school geography in order that it may meet the demands of school men. When modern physical geography was given a place in the high school, and almost universally was made the introductory science, teachers believed that it would prove to be an efficient agent in training pupils into scientific habits of thought, and scientific methods of work. Considerable reliance was placed upon the field work and laboratory work which, it was expected, would be organized and introduced as an essential part of the course.

The friends of physical geography have always maintained that laboratory and field work are just as essential in this science as in physics, chemistry, or biology. As a matter of fact, however, systematic laboratory and field work has never reached the stage of development in geography that it has reached in other high school sciences. How far this failure accounts for the dissatisfaction which now seems to exist is not evident. Doubtless, however, it has had something to do with producing this feeling of dissatisfaction. At any rate, one finds by talking with high school men that there is a widespread feeling that, as a first year science, physical geography has not met expectations. There is now on foot in parts of the country a movement to substitute something else for it. In most cases a combination of the elements of several sciences, which is termed introductory science, is recommended. In a considerable number of schools introductory science is now being tried. This experiment has not advanced far enough as yet to justify definite conclusions. However, one who has sought to find the cause of the partial failure of physical geography to meet expectations cannot discover that there is any probability that introductory science will escape the same weaknesses which have unfavorably affected physical geography teaching.

From all parts of the country come the reports that physical geography is almost universally put into the hands of the teacher

[1]Read before the Earth Science Section of the C. A. S. & M. T., Lewis Institute, Dec. 1, 1911.

whose schedule of classes permits her to take on an additional study. It is not common for the high school principal to seek a teacher especially prepared for physical geography. He is much more likely to secure a teacher who is prepared in physics or in botany, or in history, or in English, and then if she has a vacant period, assign the physical geography class to her. I have made frequent inquiry of people familiar with school practice in many parts of the country, and I find that this is common almost everywhere. No one can wonder that physical geography has proved unsatisfactory under these circumstances.

The question now arises, Will introductory science receive similar treatment at the hands of those who make out the schedule of classes for high school teachers? There is no reason to believe that it will not. The study is to be taught to first year students, the youngest in the school. It is not a college preparatory study. It is not a direct preparation for a second year in science. All of which considerations will make introductory science a convenient study to assign to the teacher who has a vacant period. Is it likely that under these conditions elementary science will succeed any better than physical geography has done?

I have no objection whatsoever to elementary science as such. More than twenty years ago when I was a student in a normal school, elementary science was taught in that school. All the students in that school were required to take it. They were advised to teach it in the schools which they entered, and it was taught in many schools. It was, however, abandoned in that normal school and so far as I know was abandoned in the high schools into which it entered. So far as the schools had experience with this subject, the experience was unfavorable. It is one of those studies which when talked about appear to be very desirable, and to have high possibilities, but when actually put to trial are usually found to be disappointing.

As Professor Salisbury has said, introductory science under the conditions which are bound to surround it, seems foredoomed to failure. Many of us remember well the great expectations that were aroused by the advocates of nature study in the elementary schools. I suppose almost every school system in the United States looked upon nature study as promising splendid things. In some schools those expectations were realized. In a larger number of schools they were not realized, and at the present time one hears far less about nature study than he heard a few years ago. Not because nature study is an undesirable

branch of education. Ideally it is most desirable, and one cannot help feeling that it ought to be successful in operation, and yet most of us have found that it was disappointing. It has been found almost impossible to find teachers who were sufficiently well qualified to teach nature study and yet who were not faddists or extremists—teachers who, while having the necessary faith in nature study, were not over zealous and expected other studies in the curriculum to yield to it.

It is probable, however, the elementary science will be widely tried. Articles are appearing in educational periodicals and papers are being read before educational gatherings, pointing out the splendid possibilities of this new study. These promises are alluring. One cannot read a skillfully written paper or hear an enthusiastic address without feeling that if the right teacher could be secured, introductory science would be a distinct and valuable contribution to the high school course. My skepticism is based not upon what introductory science ideally is capable of being, but upon what the experience of the schools has shown introductory science is likely to be.

If all that I have said were granted, it still would not be proved that physical geography ought to be retained in the high school course. Physical geography must stand upon its own merits. If it has not contributed as much in the way of training and practical information as a study ought to contribute, then physical geography must be modified or must give place to some other study. I believe that most of its friends are willing to concede that the study must be modified if it meets the reasonable demands which are now imposed upon any study in the high school. For the high school course is more than crowded. So many studies are being urged, and our complex life seems to demand such a variety of studies, that any branch which cannot justify its place in the curriculum must give way.

During the last few years the demands made by the friends of vocational training have been very insistent. One group of people is urging that agriculture be taught in the high schools. Another group that domestic science be given more time. A third group that manual training should be a required study in a part or all of the years of the high school. Still others urge the value of business and commercial courses. All of these studies are capable of vigorous defense. All of them promise definite and valuable training, and their claims cannot be dismissed. Physical geography is about the only study in the first year of the high

school that can be conveniently eliminated. English must be retained. Most people believe that algebra must be retained. Many would not consent to seeing history taken out of the course. If the student is to continue the study of Latin, he must begin it in the first year of the high school. Thus it comes about that in the pressure which is being brought to bear, physical geography is the study which is most likely to be compelled to yield, and unless it can be shown that it is capable of giving the pupil more valuable knowledge or more effective training than any of these other studies which are seeking to displace it, then physical geography will be displaced as the privileged first year science.

One who has listened to the arguments presented by the N. E. A. Committee or by the Committee of the Association of American Geographers, which, two or three years ago reported upon high school geography, discovers that there is general agreement on the part of members of these two committees that geography needs humanizing. There seems to be more than usual agreement among all who have written or spoken upon the subject that too much time has been given to the description and the classification of land forms, to the description, for example, of unusual types of rivers, such as consequent and antecedent and engrafted and dismembered rivers, too much time to strained classifications such as are found in one text-book which describes eight kinds of lakes, or another which describes eight or nine kinds of plains.

Physical geography is, after all, a relatively young science. It has been easy to determine its center, but impossible to locate its circumference. Furthermore, since college men have largely governed the content of high school physical geography, there has been a tendency to introduce into it much that really belongs in the college course. At the present time, almost every text-book which was actually written for high school use, is used in colleges. In the University of Wisconsin, we are carrying on three courses in physical geography and in each one of these courses the text-book used was written by a college man for high schools, but we find these books suited to our needs in the university. Manifestly, there is need of a closer discrimination between the facts of elementary physical geography and the facts of advanced physical geography, and it ought not be difficult to agree upon the major portion of the facts which ought to be left for college study, if they are to be studied at all. School men who have expressed themselves upon the subject are generally agreed

that many of the facts which deal solely with the physical phases of geography may be omitted in order that room may be made for facts that are highly valuable but which are not strictly a part of *physical* geography. They are rather a part of either commercial geography or industrial geography, or political geography, or some other phase of geography which deals with man's activities and interests.

At the present time, everyone who is engaged in teaching pupils who come from the high schools realizes how woefully lacking these pupils are in a knowledge of the elementary facts of general geography. It is a common thing for us to find in our freshmen classes that from one third to one half of the students cannot tell even in what country great rivers like the Volga, or Ganges, or Rhine, or Orinoco are found. It is not uncommon to find college pupils who know little about the leading industries of a great country like Germany or France; who cannot locate such cities as Buenos Aires or Calcutta, or Moscow or Madrid, or Edinburgh; who even regard Portugal as a city; who cannot tell the difference between latitude and longitude; who have not, apparently, any conception of the causes which produce our change of seasons. I have made it a practice in recent years to give to our classes in college geography tests in these elementary phases of the study, trying always to ask perfectly reasonable questions, questions which my colleagues in other departments of the university have recognized as a reasonable expectation from any educated person, and yet we find that these pupils make a sad showing.

I do not speak of this in criticism of the teaching which is done in the grammar school. From a considerable number of years of close contact with grammar school work I am persuaded that the geography teaching in the grammar schools is as well done as it is in the high schools or the university. In my judgment the fault lies in our practice of considering that because these phases of geography were taught in the grammar school, they will be understood and permanently retained, while experience shows over and over again that they are not well understood and are not retained, and that we cannot proceed on the assumption that pupils do understand these common facts of geography.

Now, if years of observation in many normal schools and colleges show that those phases of geography which people most need are not generally understood by high school or college students, then it seems sensible that we should recognize the situ-

ation as it is and proceed accordingly, and not close our eyes to the facts and say: "I know the students don't know these facts, but they ought to, therefore it is not my business to teach them." It is difficult to see how we can justify ourselves in any such course. The fact is, that some universities are now giving courses whose content, to a considerable extent, is simply a maturer study of the facts usually taught in the grammar school, but frequently not understood when taught, and because not understood, are not retained. And unless those facts are elaborated and impressed in later years, the pupil goes out from his school life with a meager fund of geographical knowledge.

In deciding, therefore, what ought to be the content of high school geography, we must be governed by two considerations; first, the educational needs of the pupil, and second, the practical needs of the pupil. By educational needs I refer to the need of intellectual training, sometimes called mental discipline. By practical needs I refer to the needs which every intelligent person has for a fund of knowledge about the world in which he lives and which it is the province of geography to teach. No one who knows the actual working of physical geography in most high schools will claim for a moment that this study, *as it is taught*, possesses any particular disciplinary value. If taught as we all think it ought to be taught, it would possess disciplinary value, but 15 years of effort to have it so taught have not resulted in any satisfactory outcome, and while some of us have been trying to teach physical geography for its disciplinary value, we have been neglecting those phases of the study which are of greater usefulness. It is apparently clear that the efforts to make physical geography in high schools a highly disciplinary study are nearly a failure. The course left open for us is, therefore, to recognize high school geography as a study capable of giving the pupil a knowledge of many things about the world in which he lives, things which every educated person is expected to know and would be glad to know. Knowledge about the great nations of the earth; the nations which are directing the affairs of the world, as Germany, England, France, Japan, United States. Every person would be glad to have a fuller knowledge of the resources and possibilities of Argentina, Brazil, China, South Africa, and Canada. These countries are not at the present time in the front rank, but they are rising to importance. They are taking a part in the world's active doings. We have got to reckon with them in the future.

This is an age of commerce and of industry. The foremost aim of the leading nations of the world, aside from maintaining their own political integrity, is to expand their trade with foreign nations. The great competition between Germany, Great Britain, and ourselves is trade competition. Nations are extending their territory in order that they may extend their commerce and give fuller employment to their own people at home in manufacturing the goods which they sell.

The contest between Russia and Japan, the aggressions of Russia in Asia, the ambitions of Germany, our own ambitions, are all closely related to commerce and to other economic considerations. Large numbers of men are needed for our consular service, large numbers for the government service, and large numbers of men are needed in business, men who are capable of appreciating the geographical factors in the economic problems of the day; and all international problems have to a greater or less extent a geographic basis. It is the province of geography to introduce pupils to these problems, and to teach them something of the geographic foundation upon which these economic problems rest. High school geography cannot delve deeply into such matters. It can, however, do something toward introducing young people to these problems and it can give them a basis of intelligence for thinking about them in the future.

If what I have said is true—and it seems to me that it is true—geography in the high school must be given a somewhat different character from that which, in the majority of cases, it now has. There is no reason why *physical* geography of both the elementary and advanced type should not be taught. There is no reason why those who desire to have a detailed knowledge of land forms and of physiographic processes should not have an opportunity to receive instruction in those phases of the study. Perhaps physical geography ought to be offered as an elective in the upper years of the high school, as it was recommended that it should be by the Committee of Ten in 1893.

Unquestionably courses in pure physical geography ought to be given in the colleges, but responsibility does not end there. There is another phase of geography which has as great possibilities of training and greater possibilities of usefulness, and those are the phases of geography which may be broadly classed as *economic*. The appreciation of the economic phases of geography rests upon a knowledge of the main principles of physical geography, and I believe no one would advocate a course in

geography which was not based upon a study of the fundamental principles of physical geography. That the instruction should be continued on into the economic phase does not seem doubtful. Studies were justified in the past solely upon the basis of their disciplinary value. Studies at the present time cannot be so justified. The ideals of our age, whether rightly or wrongly, have undergone a change, and everywhere intelligent men and women are demanding that education shall make for efficiency; that scholarship is not the only purpose of education; and that scholarship and efficiency are not synonymous. Everywhere people are saying that our school instruction must better equip young men and women for taking a place in the world's affairs, and that the 8 to 12 years of instruction which they have received in the public schools shall go farther than it has gone in fitting these young people to do efficient service in the world of men; that their education shall not be such that it must be begun anew when the pupil enters some active calling in life, but that he shall find that a considerable proportion of what he has learned in the schools is useful to him in his later life.

I recognize that many people do not believe in this doctrine. Unquestionably the unlimited acceptance of this doctrine will lead us astray. Perhaps the present tendency of education is too strongly toward the utilitarian. But the way to meet the present situation is not to insist rigidly upon old standards of education and not to oppose unqualifiedly the new ideals. Our education is undoubtedly to-day going too rapidly toward the vocational and utilitarian side. Undoubtedly, we are likely to be swept from safe moorings, but the way to prevent that is not to oppose all change, but to seek to hold fast to that which is good in the old, and to reach out for the best in the new.

If it is true that the demands of our age call for young men who have been trained to think upon some of the problems which an industrial and commercial age imposes, if the lifework of a large proportion of our educated young people is to bring them in contact with economic problems, then it is the province of geography to give some emphasis to the economic phases of the study. It cannot be said that commercial geography as it is generally presented, is thoroughly satisfactory. It is a little too much like Homer's catalogue of the ships. Doubtless too many details are introduced. But granting all this, it still seems that what the second half year of the high school course in geography needs is a well-balanced, well-worked out study of the ele-

mentary side of economic geography; not necessarily commercial geography alone. At the present time writers of text-books and publishers hesitate to call a text-book an economic geography. We shall soon cease to fear that word. Commercial geography is now a more popular term. The fact is that modern demands require that a well-educated person shall know more about the geography of industry, of agriculture, and of trade, than the ordinary courses in high school geography give. The pupils need to know more about the resources of their own country and of other leading countries than they now know. Pupils need to know more about the location of great productive areas of the world, and reasons why certain things are produced in these regions; more about the climatic basis and physiographic basis which underlie industries.

Furthermore, it seems to me that the course in economic geography should be purposely shaped to meet the probably future needs of the pupils. In rural high schools, where it is likely that a majority of the pupils will live on farms or among farms, agricultural geography ought to receive a considerable emphasis and it seems to me that someone would perform a distinct service who would write a physical geography with a strong agricultural trend; in other words, an agricultural physical geography. I further believe that someone would perform a distinct service who would write a text-book in which economic geography shall be closely linked up with the fundamental principles of physical geography, including climatology.

I do not believe that the same course ought to be given to pupils in the cities, many of whom will never be agriculturists, as should be given to pupils most of whom will be agriculturists or will live in agricultural communities.

My present feeling is that there is a need of two distinct types of geography for the second half year of the study. The first part we are agreed should include the fundamentals of physical geography. The second part should be, in one case, closely related to the subjects of agriculture and agricultural economics. The other should be closely related to the economics of trade and production. In both these courses locational geography, through the study of maps, should be emphasized, and in both, laboratory work and field work should be encouraged, though it does not seem hopeful that any great amount of field work will be accomplished. There should be a consistent aim on the part of teachers of these new courses to equip pupils with a knowl-

edge of the countries and peoples and cities of the world, and to give them a more definite knowledge of where these nations and peoples and cities are.

In conclusion, my plea is for a half year of physical geography from which the more technical and specialized details are eliminated, and into which more of the human relationships are introduced—a second half year of geography based largely upon the probable needs of the pupils who are taught, with a strong economic flavor in either case, with a systematic study of maps, a constant reading of supplementary articles which keep the pupils in touch with the current affairs of the world. Such a course will not be any less disciplinary than the present physical geography, and it ought to be of more practical value. I believe that by such a modification of the course in geography, we shall be able to place in the high school curriculum a study which all people recognize as highly desirable but which in its physical phase alone can never prove fully satisfactory in an age dominated by economic ideals.

A REVISED EXPLANATION OF THE ACTION OF THE SIPHON.

By Albert E. Hennings.

The explanations of the action of the siphon offered in many of the text-books of physics prove to be either confusing or faulty when closely examined. An outline of two current explanations will serve as a basis for comment and comparison. If P represents the atmospheric pressure, then, according to the course of reasoning in the one case, the upward pressure at *a* (Fig. 1) is P — *ab;* that at *f* is P — *df*. The former is the greater by *ef* which is a measure of the force upon which the flow depends. In the second instance, condi-

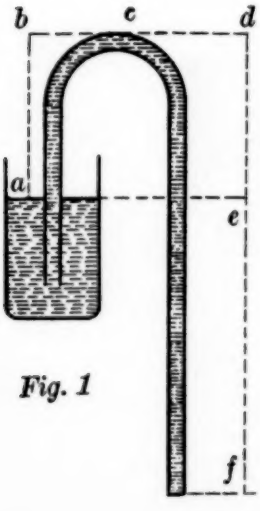

Fig. 1

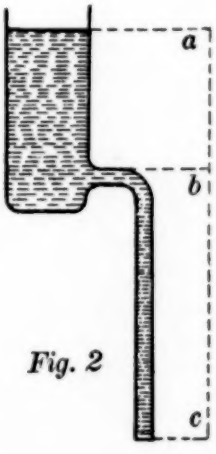

Fig. 2

tions are considered at the point *c*. It is assumed that the pressure toward the right is P — *ab*, and toward the left, P — *df*, giving *ef* as a resultant force to the right.

Now the conclusion reached in each case, *viz.*, that the "driving force" is *ef*, the difference between the lengths of the arms of the siphon, is not questioned by anyone, but it is confusing to speak of upward, or downward, pressure, and manifestly incorrect to speak of a *difference* of pressure at a *point*, when one is dealing with a liquid.

To avoid this confusion and to make the argument sound, consider the siphon at rest with the orifice at *f* closed. Then the pressure at *a* is P; at *c*, P — *ab*; at *f*, (P — *ab*) + *df* or P + *ef*. It is this state of affairs which sets the siphon going when the pressure applied at the orifice is released. The effective driving force is indeed *ef* as before, but the absolute values of the two forces of which this is the difference are not in agreement with those assumed in the two arguments cited. Nor is there any question as to which of the three is to be preferred, for certainly there is no *difference* of pressure at *c*, and the pressure at *f* is unmistakably greater than that of the atmosphere.

That the above analysis is absolutely sound may be convincingly established through the consideration of a simple case of hydrostatic pressure. (Fig. 2.) The driving force is obviously *ac*. It is the difference between the pressures at *a* and *c*, the values of which are respectively P and P + (*ab* + *bc*). It would be absurd to say that the pressure at *c* is P.

COAL MAP OF THE UNITED STATES.

A special and valuable feature of the report on the production of coal in 1910, issued by the United States Geological Survey, is a series of maps showing the known coal fields of the United States. These maps are printed on a scale of about forty miles to the inch, and if pieced together would make a map the size of a large six-foot wall map issued by the Survey. The various classes of coal areas are indicated by a variety of colors. The coal fields are shown to have a wide range, both as to character of coal—there being half a dozen grades from anthracite to lignite—and as to present knowledge concerning the deposits, ranging all the way from the results of detailed surveys on which an almost exact estimate of tonnage can be based to the very general information that the area is underlain with coal-bearing rocks which probably contain coal that may or may not be found at minable depth. All this information is portrayed on the maps by colors or symbols.

The maps show the county subdivisions in the several states and are therefore the most exact coal maps yet issued. Geologic work by the Survey in the coal fields is in constant progress, however, especially in the public-land states, so that even these maps are admitted to be imperfect, in the light of new information continually acquired.

THE TEST OF EFFICIENCY IN TEACHING PHYSICS.[1]

By W. C. Bagley,
University of Illinois.

It is impossible to touch the problem of determining teaching efficiency in any field without first providing an answer, satisfactory to ourselves at least, for a preliminary question—namely, the question of function: What are the possible and desirable outcomes of teaching in this particular field? It seems to be peculiarly difficult to answer this preliminary question satisfactorily for any single subject that is taught in our schools and colleges. The problem of educational values is not only the most important problem in education; it is also the thorniest problem. It offers unlimited opportunities for speculation; unlimited opportunities for dogmatizing; unlimited opportunities for differences of opinion and very few opportunities for anything in the way of really constructive thinking—for to think constructively one must have facts and principles at one's command, and of real facts and valid principles there is still a sad dearth in what we like to call the science of education.

The natural result of this condition is an almost appalling lack of agreement among educators regarding both the possible outcomes and the desirable outcomes of teaching any subject. Physics is no exception to this rule, as is abundantly testified by the very interesting symposium on the aim of teaching physics which was published a few years ago in the official journal of this association. One man states vehemently that the primary purpose of instruction in physics is mental discipline; another is equally certain that physical laws must be so imparted to the pupil that he can recall them and apply them to the situations that will confront him later in life; still another asserts that the explanation of natural phenomena is self-justified and that the teacher may be satisfied if his pupils understand certain factors that would otherwise mystify and puzzle them; and there is at least one contributor to the symposium in question who would throw all discussion of ultimate outcomes to the four winds and rest content with the simple and seemingly satisfactory statement that the aim of teaching physics is to teach physics.

The last-named attitude toward the problem has much to commend it, for whatever ultimate outcomes one may desire, one

[1]Read before the Physics Section of the C. A. S. & M. T., Lewis Institute, Chicago, Dec. 1, 1911.

must admit that a knowledge of the subject is a fundamental condition of their attainment. The student of education, however, cannot rest content with this simple statement of aim. He must recognize that it formulates the conditions under which the first steps must be taken, but he must also remember that a mastery of the facts and principles that any science presents is not a guarantee that the educational value of the science has been adequately realized. What, after all, do we mean by "knowing physics"? How much of the body of knowledge that physics comprehends must one have mastered in order to "know physics"? For how long a time must these facts and principles persist in one's mind in order to entitle one to the distinction of "knowing physics"? If you think that simply stating the aim in this way is an obvious and simple way out of the problem of educational values, you might try to answer a few of these questions. The very first question—what elements out of the total body of physical knowledge should we give in the high school course?—involves one at the outset in the question of ultimate outcomes. It means that one is making a selection; and an intelligent selection involves some principle of selection—some norm or standard; and here you are right in the midst of the problem of values, and you must have your theory of values. And if you are confronted with one of the very few undisputed assertions in educational science, namely, that the average student in the high school will inevitably forget a large number of the facts and principles that we teach him, you are almost certain to justify your teaching by asserting that the training in thinking that he obtains will stick anyway, even if the details are forgotten; or you will say that having cleared up some puzzling natural phenomena may enable him to live more happily and more comfortably even if he forgets precisely how they were explained. You are perhaps justified in making these assumptions; their validity is not the point at issue just now. I am simply asserting that the question of ultimate outcomes is bound to present itself, and that the efficiency of one's teaching can in the end be measured only by determining how far these ultimate outcomes have been realized.

The difficulty that confronts us in measuring the outcomes of teaching lies chiefly in the fact that we tend to formulate these outcomes in psychological terms—in terms that represent subjective states or processes rather than objective conditions. A measurement to be useful must be objective, and the only way out of our difficulty is to translate these subjective factors into an

objective form. The psychology of to-day is attempting to do this. The science of mind is becoming transformed into the science of behavior—the science of conduct. This point of view promises to be most helpful to the cause of education for it suggests a set of objective standards which we may be able to construct and to apply to the problem of determining the efficiency of our work.

Let us consider for a few moments the possibilities of this suggestion in the teaching of physics. We shall assume that the justification for the teaching of physics in the high school lies in the fact that the study of this subject may influence the conduct of our pupils in the direction of greater efficiency. What, then, are some of the factors controlling human conduct that the study of physics may leave with our pupils? Can we catalogue these controls so that we may test our teaching by determining in how far objective conduct or behavior indicates the presence of these subjective factors that we are attempting to develop?

The one certain, direct, and unquestioned method of modifying the conduct of our students is to develop specific habits—immediate and automatic reactions that will occur inevitably when the proper conditions are present as a stimulus. The trouble here lies in the fact that, however well we may develop these specific habits in the school, they may fail to function later because some unique factor which set them off in the school does not make its appearance in the situations of later life. A high school principal complained to me the other day that, while his pupils habitually did neat, well-organized notebook work for one of his science teachers, they did slovenly, careless, unorganized work for another. In this case the habits failed to "transfer" from one laboratory to another. In essence, this is the crux of the problem of formal discipline. Specific training very often fails to "spread;" it is generally recognized that it will spread under certain conditions, but how to fulfill these conditions is a practical problem that causes us no end of difficulty.

It still remains true, however, that, irrespective of the possibility of transfer, certain automatic bases must be laid in every subject that is taught if any valuable outcome whatsoever is to be realized. The glaring defect of present-day tendencies in educational theory is the disposition to minimize the importance of that patient, repetitive procedure which is absolutely essential to any outcome that is worth while. Certain associations must be made so thoroughly automatic that they will be just as inevitable as the

fundamental tables of arithmetic. It takes time and effort to do this; in many cases, there must be something that smacks of drudgery—and against drudgery in any form, modern educational theory and practice, in America at least, reacts negatively and emphatically.

To aid the young teacher (and the great mass of our high school teachers are young women and young men themselves just out of college) it would be well to prepare for each subject a standard list of the important specific habits that must form the automatic bases upon which any real progress in the further study of the subject must rest. If such lists were constructed coöperatively by men of recognized authority, they would, I believe, be of inestimable service to the beginning teacher. They would give him a set of standards by means of which to measure one important phase of his teaching. We have an approach to this in the syllabi that have been constructed by various bodies of teachers, but what I am urging is something more specific and detailed than these. It is a list of the fundamental habit-factors—the formulæ that must not only be understood and rationally derived, but also fixed permanently so that they will be expressed just as automatically as the multiplication tables; the specific habits of skill in the manipulation of laboratory apparatus that are fundamental to all future laboratory work and which should consequently be fixed permanently at the earliest possible moment; the basic definitions that need to be memorized if you can get anyone to admit to-day that memorizing definitions is an essential step in the mastery of a science. I speak here as a layman in the teaching of physics—as a "rank outsider" in fact. But perhaps even a "rank outsider" has a right to testify that he cannot depend upon the knowledge that we presuppose every high school graduate to possess from that very fact that he has taken a high school course. The preparation is untrustworthy because, while the *knowledge* has been imparted in the high school, fundamental *habit-bases* ave not been laid. To take an illustration from another subject; I gave to a university class a few days ago a list of important dates in American history, asking them to tell me what events were associated with the dates. I found only one date that was accurately and unerringly associated with its important event by every member of the class, and that was 1492. Sixteen per cent of my university juniors and seniors were uncertain as to what happened in 1776; seventy-four per cent did not have the year 1789 connected with anything that was significant to our national

development; ninety per cent were ignorant as to the meaning of the year 1783. I instance this merely as an illustration of the lack of these automatic bases. I took up the matter with one of my colleagues who is a recognized authority in the field of American history. His own experience has been similar. He told me he could not in his university classes safely assume that the students coming to him had any dependable knowledge of the subject. Now dependable knowledge is knowledge that has a good firm foundation in fundamental habits, and it is in laying these foundations that the teaching in our American elementary and high schools is notoriously weak. The prime cause of this weakness, I believe, is the uniform youth and inexperience of the great mass of our teachers in the lower schools. They do not know what to emphasize; where to put on the pressure; how to separate the fundamental from the accessory; how to distinguish between the immediate rational understanding of a principle and the firm fixing of that principle so that it may be of permanent service. Lists of standard habits if carefully prepared by experts in the field would be of great value to these young teachers.

Care must be taken, of course, that the beginning teachers have a clear perspective, or we shall run the serious risk of a return to the reign of formalism and memoriter work which characterized the schools of another generation. But this factor could, I am sure, be safeguarded. And just now in American education we need a renascence of thoroughgoing drill and discipline. The movement has already been initiated in the elementary school. The laying of automatic bases in language, in number, in writing, and in spelling has recently assumed a new importance. Not only are effective drill methods being developed, but standards are being carefully and painstakingly worked out. We already have a very satisfactory set of standards for penmanship, so constructed that the fifth grade teacher or the sixth grade teacher may, for example, take a set of her pupils' papers and evaluate definitely, by comparison with the standards, the progress that the pupils have made under her instruction. A similar set of standards is being prepared for composition. I am convinced that the general principle is applicable to every subject that is taught; for, whatever may be the ultimate outcome of the teaching, it is clear to all that certain fundamental bases must be laid and that the efficiency of the teacher can be measured in part by his success in laying these bases adequately.

I should not have it thought, however, that the task of evalu-

ating the results of our work in respect of the indirect and remote and ultimate outcome is entirely hopeless. From your laboratory work in physics you doubtless wish, not only to fix physical laws more tenaciously in the minds of your students, but also to leave with them a working conception of the method that physical science has developed to discover and test these laws. You hope that they will think more clearly for having had the discipline of this laboratory experience—that they will be better able to draw correct conclusions from whatever data are involved in other problems that they face. On the surface, it seems difficult to devise a test that will determine in how far our efforts toward this end have been effective. And yet, if our teaching has really hit the mark, the results ought to show somewhere; it ought to be possible to bring our students face to face with typical situations, differing in some respect from those that the laboratory work involves; it ought to be possible to determine whether the method that we have been impressing is really applied in a way which shows that it has been definitely grasped and adequately appreciated. A friend of mine who teaches one of the laboratory sciences in a secondary school devised a test of this sort. He simply took a set of conditions constituting an entirely new problem that might be profitably attacked by the exact methods of science. He brought his students face to face with this problem and asked them to write down the steps that they would take to solve it. He had divided his class into two sections and he had taught the two sections during the term by different methods.

He found that one section did attack the test problem more intelligently than the other; in short, he found that one group of his students had a better working control of the scientific method than the other had; and the fact that both sections were approximately equal in other respects led him to infer that his teaching might have been a factor in the development of this control. Had he given both sections a similar test before beginning his term's work and compared the results of this preliminary test with the final results, his conclusions, of course, would have been more valuable and if he had further subjected two other similar groups of students to the same initial and final tests without giving them the intermediate training, whatever conclusions he reached would have been even more suggestive. But the point is simply this; one may devise tests that will measure so seemingly elusive a factor as the control which one's students have gained over a general method of procedure. The measurement will give only

approximate results, and investigation in the field of education must be continued for a long time before we can hope to develop our procedure to a point where it is safe to generalize. But all of the sciences have been evolved through a similarly slow and laborious and patient process.

Tests of this type or of any type probably that finite mind can devise, must always leave a margin of unmeasured and perhaps unmeasurable factors. That one *can* think better is, of course, no guarantee that one *will* think better in any particular instance. Whether our teaching of physics has given our students an initial command of the procedure of science may be determined by some such means as I have suggested; but whether the procedure has not only been abstracted from the matrix of details in which the student first finds it enmeshed—has not only been lifted to the plane of general concept of procedure—but has also been idealized as a worthy procedure to follow and made a dynamic element in his mental equipment, this is to be tested only by his later conduct in life.

It is, of course, the emotional and inspirational factors that really give life, vitality, and dynamic value to any really effective teaching that we do—even in the field of sciences so objective, so rigidly intellectual and seemingly nonemotional as physics and mathematics. The spirit of science which quickens and vitalizes its method is something that must be caught—it cannot be taught. And yet the thing that should be caught depends, after all has been said, upon this thorough basis of specific habit that can be accurately measured, and upon a working grasp of method as method and here the strength of our students' grip can be at least roughly determined.

DEVELOPMENT OF FRAIL CHILDREN.

In a paper containing the results of a careful study of 109 children ranging from birth to thirteen years of age, Dr. Richard B. Smith of Grand Rapids, Mich., concludes in a recent issue of *The Journal of the American Medical Association*, that the frail child presents the following fundamental characteristics: Frailness, lack of fat, slenderness of muscle, lack of vigor in body development. The muscular insufficiencies of later life in frail women are common in frail children. The lessened ability of such a woman to fulfill the duties imposed on her, the limitations placed on her by her lack of vigor and the unhappiness which such women in a state of fatigue endure are serious matters with her. More might be done in the way of prevention. The frail child should be more clearly recognized and its tendencies more intelligently fought. In a large number of instances it is possible to maintain a fair state of nutrition in such children and to direct them to a more vigorous womanhood. When such is uniformly done, it will do away, to a certain extent, with the neurotic women who form such a problem in everyday practice and in almost every specialty.

EFFICIENCY IN GEOMETRY TEACHING.[1]

A Study—An Experiment—A Result.

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One of the recent questions in education deals with efficiency in the secondary schools. The question is of vital importance to everyone, but to no class is it more pertinent than to the high school teacher of mathematics. Mathematics has held an important place in the courses of study in the past because of the supposed value it gives in formal discipline. This idea now challenged, together with other causes has brought about the violent agitation of the question of how to present high school mathematics, the arrangement, the amount and the kind for each grade, in order to meet effectively the needs of the citizen of to-day. For this purpose improved texts have been published, new material presented in the elementary school and in the high school, mathematical associations organized and committees appointed. Yet in spite of these forces and many others, the teaching of high school mathematics has not yet reached its maximum efficiency. In order to reach a higher degree of efficiency in the teaching of geometry the following study was made and a few conclusions drawn.

The underlying principles of any subject must be understood. Geometry, a study founded upon definitions, axioms, postulates, problems, or theorems has too often been presented to the pupil as a medley of unreasonable, trying situations that have nothing to do with life. The assumptions laid down in geometry may mean and quite often do mean anything that the user sees fit to decide upon. This gives wide latitude to the teacher in the selection and arrangement of working material, but too many have failed to see their opportunity. The tendency of the past few years seems to have been to get away from the pure Euclidean idea and back to the fundamental beginnings. This tendency to change has been attended, as all changes are, by much waste. The text-book writers who have favored a change have held back because they knew that a book that was too radical would not be used, and teachers who were anxious for a change were held in abeyance to custom by fear. Some of the writers in their eagerness for a change have confused themselves by attempting correlation

[1]Read before the mathematics section of the Missouri State Teachers' Association at Hannibal, Nov. 10, 1911.

with physics[2], astronomy and other subjects. Others have tried the heuristic[3] plan, and others the plan of induction,[4] while others, each in his own way, have advocated a geometry that was more concrete, practical, inventional,[5] and empirical.[6]

My thesis is that geometry teaching in order to reach its highest efficiency is neither to make a geometry of "real" or concrete problems nor one of the purely demonstrational type; but rather a presentation of geometrical principles in a concrete way at first followed by the logical, demonstrational type. There is no need of purely utilitarian problems nor purely cultural problems. Whatever is utilitarian is cultural and whatever is cultural is utilitarian. An education that is complete is one that educates vocationally and liberally. The only reason for the present division existing is that our ideas are so faultily worked out that we are not able to see the coördination of the two. At an early age a child is able to build block houses and to work with material that has surface, length, breadth, and depth; he sees triangles, squares, and circles. In the third and fourth grades the home geography with its directions and location employs many of the elementary principles of geometry. In his map making he uses cross-section paper, with the cross roads as his coördinate axes; or if in the city he uses the main streets. The work is continued in geography with respect to latitude and longitude where the equator and prime meridian are the axes. In many of the rural localities the polar coördinates are the basis of location work, especially in directing from one place to another. Nor is geography the only field; the work in agriculture calls for platting of ground either for decorative or practical purposes, and also for architectual forms that are so in evidence about any farm.

The problem of the township with its townships and range lines, together with the section gives a better idea of surface in square units than can ever be obtained from a study of ordinary geometry in that the area of a rectangle is the product of the length by the altitude in terms of a unit square. Again in games and play, as baseball with its diamond, tennis with its court, football with its field, and many others that call for angles, straight lines, area and other geometrical forms. Nor is this all since the child must learn in farm accounts or commercial activities that

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[2]Iles, My Class in Geometry.
[3]Hopkins, Plane Geometry.
[4]Sanders, Plane Geometry. Shutts, Plane Geometry.
[5]Spencer, Inventional Geometry.
[6]Warren, Experimental and Theoretical Geometry.

he must make computations based upon data that has been secured in topographical leveling, soil surveying, excavations, drainage ditching, grades for streets and subsequent platting.

A great many of the elementary principles of constructional geometry can easily be given in mechanical drawing in the eighth grade. And there is no reason why the child should not be taught to draw to scale some measurements of his own made in the school yard or surrounding country. Practical problems that one can use in geometry are continually coming up. The engineer has to deal with questions of force and motion, strength of materials, the architecture of houses and bridges, and similar problems. The farmer, the carpenter, the mason, and all other artisans, are confronted with problems each in his own field. And these activities are so interwoven that it is impossible to understand clearly one unless something is known about several.

The child as well as the teacher should know the objective point, and the material with which he is to work to arrive at that point. The pupil should always understand why he selects a certain process. In material construction the boy is taught why he uses the try-square at one time, and the T-square at another time. In the construction of a house the boy can see the advancement made in the building, and why at one time certain scaffolding is needed and at another time something else; and in the same way he should see how he builds his geometry. If he knows the purpose he stands a chance of becoming a discoverer. "The pupil must know from the beginning what is aimed at, if he is to display and employ his own strength in the effort of learning; and he will employ it provided he knows definitely what is to be reached. To lead him unconsciously by question and task whose purpose he does not clearly see, has the disadvantage that neither a free rising mental activity nor a clear internally connected insight takes place."[7] This means that the child should see some reason for the assigned task.

Neither should beginners be limited by restrictions. Their life and experiences have convinced them that certain statements are or are not valid. It is bewildering to them to be required to prove a statement by means of other statements that they have not experienced, and to be careful not to let intuition and former experiences enter into the proof in the slightest degree.

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[7] A. L. Baker, Purposive Geometry, SCHOOL SCIENCE AND MATHEMATICS, 1906, p. 511.

The teacher must ever bear in mind that not only is the subject new, but that the activity is new. The proof that right angles are equal is foolish to the wideawake boy of fourteen who has worked with a carpenter's square. Again, the teacher should make use of the biological experiences that are worth while, and the high school age is the age at which every boy and girl likes to be doing something.

The work should be grouped about types. This is easily done throughout the grades. A text is usually an economical tool for the assignment of certain problem material. The mathematical facts should be exemplified in the practical world. Model making, another form of paper folding, is worth consideration, if we actually construct instead of merely supposing. "In[8] mensurational geometry the balance may be used to advantage if one is careful to use homogeneous material, and squared paper finds a use in determining laws of area. Drawing to scale, a practical problem that confronts the contractor and builder, measurement of inaccessible distances, a study of parallelogram of forces, inclined plane, or images in a plane mirror, together with the elements of surveying, are some of the features of the new geometry." Actual constructions in the manual training department will mean more than any drawing that is copied from a picture. A visit to a building to study architectural form not only adds an interest but "develops the sense of the beautiful in geometrical construction and a love for symmetry." Girls find equally as much interest in arrangement of house furnishings, designs of wall paper, window and mural decorations. All of this stirs up an interest and a love for the subject, and the scope of geometry is widened. If from time to time brief historical data is given it adds human interest.

"For[9] a class just entering geometry a small equipment of ruler, compasses, scissors, drawing board, protractor, parallel ruler, squared paper, T-square and a triangle of 60 and of 30 degrees with a right angle should be provided for each pupil. In addition there should be accessible to the pupil at all times prisms, pyramids, cylinders, cones, drawing instruments, pasteboard for construction, sand for testing capacity, a trip balance, and anything else that would be of value locally, or that might be a help to the child to associate the new idea with his former experiences."

[8] J. C. Packard, Co-ordination of Mathematics and Physics, School Review, 1903, p. 791.
[9] J. C. Packard, Co-ordination of Mathematics and Physics, School Review, 1903, p. 798.

Coördination has a place if rightly presented. The work in crystallography, optics, and botany have elements in common with geometry. And other branches of geometry, as perspective drawing, may furnish material for the introduction to solid geometry. The work to most pupils can be made real and human interest aroused with problems from the activities that they are acquainted with and are interested in. Types of local influence are Pleasant Hill, Mo., with its vast greenhouse interests, and Deepwater, Mo., with its great tile industry.

Believing thoroughly that the plan discussed above had virtue in it and that it would develop accuracy in conception, accuracy in expression, accuracy in manipulation, economy in thought development, and an easy means of fixing the idea in the child's mind, some of the things desired in geometry teaching, an actual trial of the plan was carried out.

The work began with the simplest fact that had already been made the property of each child. No time was wasted in attempting to define terms the meaning of which was already more definite than any definition could make it. As the definition of a straight line in the books is confusing and the child's idea is clear, at least to him, there is no need of confusing the child by destroying his conception and implanting another. Nor did we think it worth while to accept such definitions as "An axiom is a truth assumed as self-evident," as the same truth is not self-evident to all minds, and again some of these "self-evident" truths are not necessarily true at all times. Nor did we prohibit a child from making use of things that he already knew. Folding paper gave an idea of a straight line. A walk gave opportunity for the observance of straight lines; the boundary of the school yard, right angles; the walks, of parallel lines; the angles of the yard, perpendicular lines and various other ideas. The measurements made were drawn to scale on coördinate paper. Ratio of lengths were determined by the diagonal scale and dividers; this gave the right conception, taught observation, developed an interest, and applied truth in an usable way. In addition, the child was not discouraged by rigidity or a confusion of unintelligible words. The balance and coördinate paper were used for determining laws of area. The problems selected were practical for the particular neighborhood in which the work was offered. No problem was admitted simply because it might meet the needs of some technical artisan or college entrance requirements, but simple problems in sidewalk construction, making of

road drags, cutting of handkerchief squares, and so on. The problems were short and definite. Problem material was easily found in mechanical drawing, in elementary physics, in construction of buildings, graphs, and machinery in motion. The motor belt easily shows the common tangents, either internal or external. Graphical representation of statistics, location problems, common forms of symmetry with simple objects as the capital Latin letters, problems in crystallography, as the hexagonal snowflake, botany with the radial arrangement, optics with the equal angles of incidence and reflection, or the angles of refraction, surveying, and common problems of domestic science, furnish a suggestion as to the source of the problem material. In addition, problems were found in carpentry, manual training, laboratory, masonry, blacksmithing, transportation, newspaper offices, and the other activities of the town. We had to make the problems short, simple, and definite, because the average high school pupil is not willing to spend several hours upon a problem that is long, indefinite or tedious in detail. He is not sufficiently developed to analyze a problem that is indefinite or meager in hypothesis.

All problems that presented themselves were not adapted to our particular high school, as some were too complex, some too indefinite and some called for material that was not easily associated with the child's experience. These problems were omitted.

The collection of problem material was carried on by teacher and pupil with as little reference to text-book as possible. In fact, problems from the text were discouraged. There was a tendency at first for the pupil to model his problem after some problem that he had found in a book, but this tendency soon disappeared when he found that such problems would not be accepted. The material was collected in as natural manner as possible, and in the ordinary affairs of life. The pupil in a short time became actively energetic in the seeking of problem material and found problems where he had no thought that a problem could exist. He soon came to use his tools of geometric principles, which were presented as the need demanded, as readily as one of the German pupils used his German vocabulary and more naturally. After a problem had been discovered, studied in the light of previous experience, and geometric principles applied, the pupil was urged to formulate the problem in as general manner as possible.

The pupil was encouraged to select his material from actual life, and from his own life, not someone else's. A book problem

was used only in a suggestive way, or to supplement some other problem material that was inaccessible to the pupil. Part of the book material as well as part of the other material gathered was unsuited to the idea in mind. In order for the boy or girl to appreciate the fact that there is a problem, something must be known about the situation that makes up the problem. If the pupil could not appreciate a problem suggested by another, and there seemed to be a need for that particular situation, an attempt was made to interest him in the material leaving him to invent the problem, rather than attempting an explanation of the "why" or the "wherefore" of the question.

As an example of the above difficulty a construction problem in engineering, while appealing to the ordinary boy sometimes lacked interest to the girl, because she knew nothing about the problem or its conditions, or had no interest in knowing. It was possible to interest her by a field or factory excursion or by experimentation, or by showing her that this at least added to her cultural knowledge, if she had no practical need. Or again she might have been interested by showing her the relation of the problem to wall paper designing, or the symmetrical idea of interior decoration or arrangement of a home. Even if this did not arouse an interest and an activity the engineering material of the boy was more real and held out to her greater possibility in conception than the abstract enigma found in the text, for she had a chance to try and find out, dealing with something that she could measure and verify.

In the work no attempt was made to make the theoretical subservient to the practical, but rather that the pupil could be led to see an association between his acquired knowledge and what he was gaining. This kept ever before the pupil the "worth while" of the subject. After a thorough leading up to the subject the theoretical problems with all the original exercises that time permitted were solved with all the rigor that Halsted would insist upon. This last feature of the work was very limited on account of time.

Some Disadvantages of the Method.

1. The problems overlap each other in material, thus destroying an economic principle unless extreme care is used. This objection would in the course of a few years be removed as the plan developed.

2. Differences in need and experience of individuals make mass teaching difficult.

3. There is great difficulty in creating a reconstructed environment in the school.

4. The teachers that are employed at the present are not efficient; are not acquainted with the subject-matter; do not know how to formulate problems and arrange them according to the ability or development of the pupil.

5. Lack of:

a. Strong personality of the teacher—enthusiasm.

b. Familiarity on the part of the teacher of the previous training of the pupil in method and subject-matter. This objection could be removed by a reorganization of the course of study of the elementary school.

c. Familiarity of the question of setting problems.

d. Interest on the part of the teacher for the subject.

e. Superintendent may object if the text is not completed.

f. Meeting college entrance requirements.

(Personally I do not consider the last two objections as I do not see as it matters whether or no the superintendent approves; and there is no reason why a high school should articulate with any particular school.)

Some Advantages of the Method

1. The pupil works with a known purpose. The geometrical problems growing out of the child's experience founded as they are on their own data, are worked by the pupils with an amount of interest not to say eagerness which artificial problems can never inspire.

2. The pupil works because he needs the geometrical principles in his problems.

3. The method teaches by three effective ways:

a. The child seeks and finds truth largely by his own efforts.

b. By illustrating truth by picture, drawing, and concrete object.

c. By teaching him to express himself in his own way.

4. It trains in organizing ability—facts must be organized in sequence.

5. It develops originality and independence.[10] "It helps to weigh evidence, draw accurate inferences, make fair comparisons, invent solutions, and form judgments."

6. It brings the home, school, mart, and farm into closer relation and gives a bond of common sympathy.

[10] Elliott, Efficiency in Education, p. 18.

7. Gives life and vital work—as practical utility is a good basis for school work.

8. The material and method follow the laws of mental condition as a result of growth.

9. A definite aim or problem causes the pupil to center his attention on some main idea, and thus furnishes him a proper motive for active thinking. It makes him conscious of the course he is to pursue. He knows definitely what he is to accomplish. "A[11] definite aim furnishes a motive for effort."

10. The pupil, not the subject-matter, is the center of the educational process. Instead of giving the pupil some logical truths for future use, or future forgetfulness, it makes geometry an instrument in the process of living in the present, thus giving a more useful instrument or tool for future use.

11. A good aim becomes a standard both for the teacher and the pupil, for judging the value of facts. The pupil is in a situation where he looks for the significance of facts. The systematic application of the psychological factor "suggestion" strengthens the interest and the desire to know, thus making the work easier for teacher and pupil.

12. This method helps to solve the question of relative values in school principles. The pupil learns to use his mathematics. He correlates arithmetic, algebra, geometry, physics, mechanics, and empirical knowledge in a way that convinces him that there may be a relation between school life and life outside of school. The rigidity of the solution is in no way lessened for a pupil has not proved a problem nor understood it until he has assimilated the facts concerning it.

Some Facts That Cannot Be Determined in One School Year in One School.

1. Determining the field in which the problems are best suited to the interests and experiences of the child.

2. Whether interest and knowledge of the boys and girls in respect to problem material are different, and if so, why.

3. How much supplementary explanation the teacher must give.

Many questions arise in any study and many cannot be answered until more data is gathered. One asked as often as any other, "Can the pupil stand the examination?" is best answered by the results obtained. The sophomore class in the high school

[11] McMurry, The Method of the Recitation, p. 113.

was divided according to their seats in a study hall, one section following the text in the usual manner, the other section the plan discussed. In this method of division there could be no evident difference in the equipment of the pupils. The section that followed the text was under a different teacher, but one who was well prepared and experienced. Both sections belonged in the same building. The average standing of the two classes in a formal geometrical examination did not differ materially, while on an examination of interpretation, organization, and arrangement the class following the plan discussed averaged nearly twelve per cent above the other section, and stated their ideas in a more definite and economical manner. Enough time has not elapsed to determine whether or no the matter is better retained.

"We[12] should bear in mind that real progress should not be measured by the ground apparently covered, but rather by what the child actually gets in such a way as to make it his own." Probably ninety per cent of the work learned in school is soon forgotten because the child has never learned how to make use of the material gathered. Would it not be better to learn well the part that is covered? The facts learned in school are not the most important feature of the work but it is the attitude of the mind, the habits of study that the student forms that is important. He is prepared then to go out into the world and live the life he has formed the habit of living. Any serious objection to the plan that may be considered, must first be preceded by a consistent thorough trial, unbiased and unprejudiced.

In closing it is not out of place to state that in a brief discussion of any new thing many loose ends appear. They can only be adjusted as the new activity is developed. A recast of the present teacher and curricula, a not impossible thing, to the suggested plan will bring about an education that is utilitarian and cultural, vocational and liberal, and that is the meaning of education for efficiency.

[12]McMurry, Method of the Recitation, p. 160.

HOW PLOT WORK MAY BE MADE OF MOST VALUE TO THE CLASSES.

By E. B. Collett,
Township High School, DeKalb, Ill.

In this paper I do not intend to set stakes along a path that you may follow. The discussion is intended to be simple. It is presented by one who has been working along this line, day by day, with a definite aim in view.

The topic deals with, "How Plot Work May Be Made of Most Value to the Classes." The writer firmly believes that the condition of the plot work of a school will indicate the efficient service of the agricultural department in that school. Is it saying too much to claim that the success of agriculture in our secondary schools depends on first, state unity; second, outdoor work? Undoubtedly it is becoming a serious question as to whether agriculture shall become more firmly established in our secondary schools, or slowly decline. Success hinges on results, and the writer intends to show that results hinge largely on plot work. More serviceable the plots, better the results, greater the success.

Scores of schools have proven that agriculture has a place in the curriculum. Yet some of our number gravely doubt it, considering agriculture yet an experiment.

We, here, represent the people who are clamoring for practical education. Do you believe we can have practical education unless based upon practical work? We must not get away from theory, but the theoretical should supplement and strengthen the practical. When theory ceases to work through practice we are making a miserable fizzle of practical education. Plot work is the foundation upon which agriculture stands in the high school curriculum, and the corner stone in practical education. The question arises, how can the plot work be made of most value to the classes?

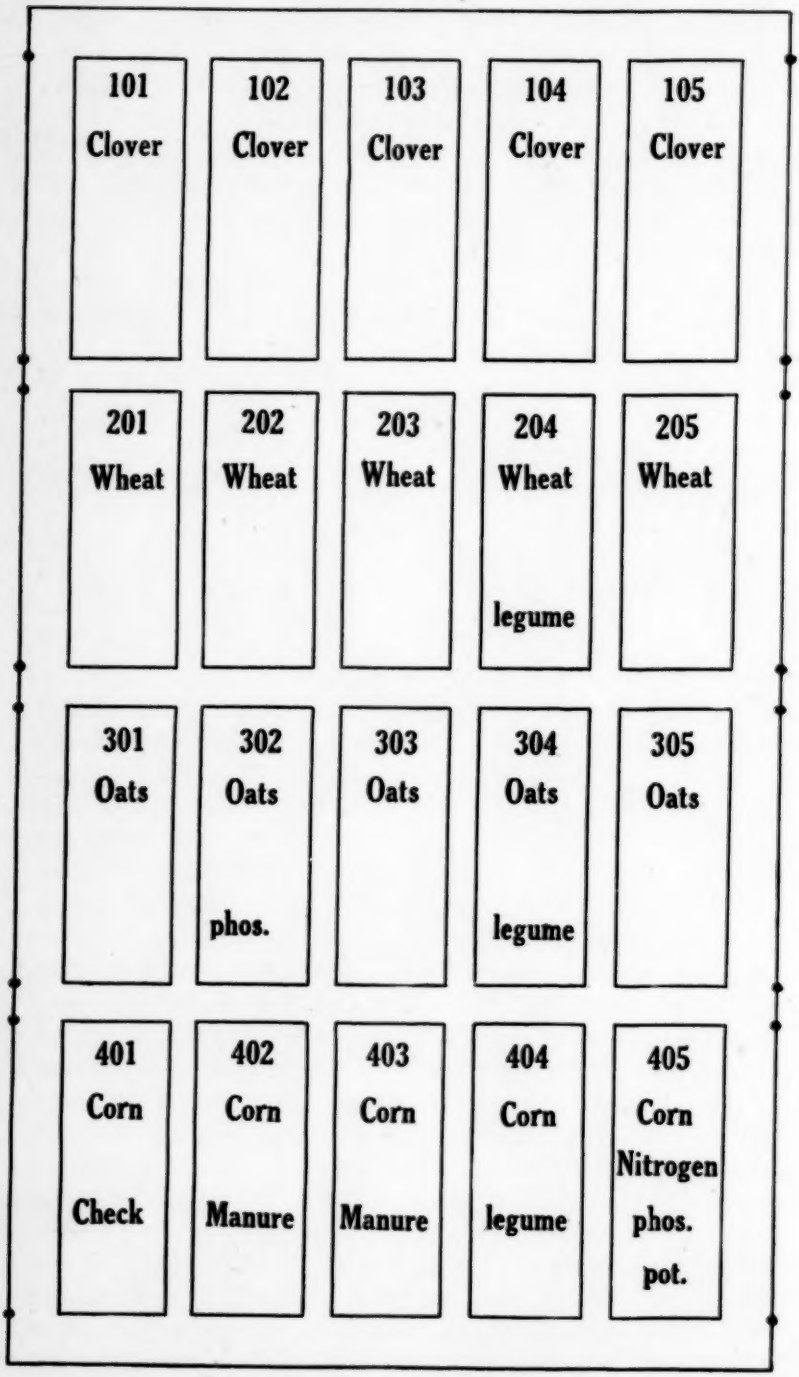
We feel that in the use of land for agricultural purpose, two lines of work should be followed: First, that of the experimental fields; a line of work having but little place in the high school, where investigation and experiments are carried on by students taking collegiate courses. Second, demonstration fields, peculiarly adapted to our secondary schools, where the plant life, and the conditions favorable for its existence can be demonstrated, as well as definite problems worked out.

At DeKalb these demonstration fields are carried on, primarily, for the students; secondarily for the community. To be of most service, we strive to avoid grandstand plays, lacking in educational value; as far as possible let the facts of our work teach; keep the work simple, and avoid profound reasons. The work is most successful when the instructor, long before, sees the dozens of problems that arise, which will insure that set of plots well worth undertaking.

Endeavoring to keep in mind the above fundamentals, especially, keeping plots the central figure, letting theory supplement practice, having the demonstrative type of plots, and letting facts teach, we have built up three divisions of plot work, first, staple crops; second, forage crops; third, orchard; each of which may be discussed under a separate head.

From the accompanying chart we can get something of an idea of how the staple crop series was laid out. For various reasons we decided upon plots one twentieth of an acre in size, with alleys running east and west twelve feet wide, with those north and south eight feet wide. To be of most value these plots needed to be permanently located. In this we finally hit upon the following plan. Fifteen feet beyond the outside plots iron stakes were driven firmly into the ground, even with the end of each series of plots. A strong chain, with a ring at each end, which would reach from one series of stakes to the series across the plots, 227 feet, was purchased and marked with iron tags where the corners of each plot would be. This chain can easily be put in position. Thus we can quickly and accurately locate one plot, or a series of plots, with small temporary stakes.

The best rotation of crops and soil treatment kept us working for weeks. We finally decided upon a four-year rotation of corn, oats, wheat, clover, for all plots. The number one series of each hundred was set aside as check, receiving no soil treatment. The number two series of each hundred, was treated with manure and phosphorus. The number three series had manure only applied. The number four series had a legume growing on each plot each year. The number five series was treated with complete commercial fertilizer. From a demonstrative point of view we feel that we are very fortunate in deciding upon this plan. We get such a variety of problems, largely practical, yet having ample opportunity of comparing the results of different series. In passing we will state but a few of these problems: the practical value of such a rotation; we try out phosphorus, so largely


101 Clover
102 Clover
103 Clover
104 Clover
105 Clover
201 Wheat
202 Wheat
203 Wheat
204 Wheat legume
205 Wheat
301 Oats
302 Oats phos.
303 Oats
304 Oats legume
305 Oats
401 Corn Check
402 Corn Manure
403 Corn Manure
404 Corn legume
405 Corn Nitrogen phos. pot.

needed in our locality; we can compare all series; the opportunity of planting clover with oats, wheat, corn; selecting various seeds; seed bed preparations; how to plant; time to plant; harvesting; selecting seed corn; method and time of applying manure; purchasing, mixing, and applying commercial fertilizers; treating seed for fungi; effect of manure on the physical condition of the soil; conservation of moisture through tillage; determining whether or not lime is needed; and the competing with birds and various insects. We have a wonderful opportunity of studying weeds. For years, some of the worst have had an opportunity for flourishing growth. Bind weed, thistles, smart weed, mustard, quack grass, and a score of others have been present. We might thus go on indefinitely sighting instances of how the work in staple crops should center around the outdoor work. Here is where we get our interest and reasons for handling the class room material.

Last year, to get a better grip on the handling of forage crops, the class was directed to go into the details of establishing alfalfa plots. From this outside interest came the best and most lasting stimulus for the study of alfalfa. Because of the need for information, as well as the self-pride which stimulates action to avoid a failure, the problems of location, soil, seed, time to plant, inoculation, weeds, cutting, value as feed, and winter conditions, were handled in a thorough and enthusiastic manner. The boys brought up questions with those outside who had tried alfalfa, and by planting time they were confident that they could succeed. They do not forget the work done on those plots, and interest remains as they look forward to the next spring's growth. Members of the class have since told me why So and So didn't get a good stand, and members outside the class have been anxious for the details of how the plots were so successfully established, and what has yet to be done to get the best of future cuttings. Thus you see how these plots are the foundation for the study of the forage crops. The more ways we can tie them into the theory of our work the greater their service.

Last spring the board of directors gave us permission to establish a small orchard near the athletic field. Naturally, the instructor had thought over the various points that would make this line of practical work worth while. We then began looking up nurseries, getting catalogues, selecting kinds and varieties of trees adapted to our locality, figuring out the distance apart of planting the various kinds of trees, looking up planting points,

studying up on pruning, and the general care of trees and fruits. We also purchased a dozen and a half of standard grapes, which call for the understanding of training and pruning of vines. From these, at pruning time, we can start cuttings that may be distributed to students and planted at their homes. Later as trees get older spraying and pruning will become more prominent problems. We are now planning to start a good many trees from seeds, which will later be grafted and put to good use. Some of this work with pot cultures and winter flowers, brings up the need of a greenhouse, which we expect will be built when we are ready to present its practical value and need in our work. From interest in the orchard there is but a step to the interest in tree surgery, followed by forestry and home decoration.

Lately considerable progress has been made on the campus in the planting of decorative shrubs. We expect, next spring, to add to our orchard and also plant some garden shrubs. We do not feel inclined, at present, to consider gardening, largely because of the lack of time to devote to that kind of work. We have found this truth exceedingly helpful, however: Every avenue where practical work can be connected with numerous fundamental problems, and furnish the purpose and inspiration for indoor work, justifies its place in the course. If the teacher understands the plot's purpose, there is no danger of being led astray.

The writer has taken the liberty, in this paper, to translate plot work, broadly, to mean any outdoor practical activity carried on in connection with work in the class room; thus giving opportunity for a brief discussion of work with live stock. With us, our text work on judging animals has been that we might sensibly judge the worth of a living animal. Trips to homes, farms, barns, are planned where animals under consideration can be studied. Sometimes boys of the class provide stock to judge. To be of most value, the boy finds that he needs to study, for the purpose of applying that knowledge to an animal that he may have before him. This need of realization may be made prominent in various ways by the wide-awake teacher. For instance, before taking up the study of the horse, we might have a sample brought before the class, and by carefully planned questions, the members of the class be led to realize that there is much about the animal, valuable to know, of which they have not dreamed. Then members of the class might look at the subject as practical horse buyers, or as keenly interested in the race, or really need-

ing a good draft horse for use, or wanting to air his knowledge before father at home. In any case, humorous circumstances come up, lending zest and interest to the fundamental problem. We appreciate the fact that without a careful teacher this phase of work may be overdone and the whole boat upset, leaving a sorry mess of pupils, teacher, and course.

Feeding problems and dairy cow records must necessarily be carried on at home, both having peculiar difficulties and demanding considerable thought and supervision, by the teacher, to have them satisfactorily completed. If a teacher makes a study of difficulties, he learns to avoid pitfalls, and later can direct successfully some lines of practical demonstration that he previously considered almost impossible.

Letters of inquiry along the trend of this paper resulted in but few answers giving additional information. The high schools of our state, I fear, lack the united effort that does so much towards reaching a higher general standard. Some of our number lack experience, and sometimes without seeing through a proposition try experiments that are impractical, make a few failures and give up.

If one works sanely with students, I see no reason why the teacher's attitude need be antagonistic towards the home. Parents do take interest in what their children are doing in school, and should feel in harmony, especially, with lines of work, the value of which they can see.

Regarding expense, we have, outside of a school farm, no more right to expect financial profit than from any laboratory course. It is not a money-making proposition. It will not pay for itself (although it does surprisingly help) ; but for demonstration, if judiciously handled, it can't be beaten.

The work during the summer months is only handled satisfactorily, as I see it, by the teacher being hired by the year, or for needed time of the vacation months, to work and see that what he cannot do is done. Students may be notified by post card when harvesting, thrashing, or hay cutting is to occur, and several may be present. At any rate, permanent data must be kept and put in suitable form for the beginning of the next year.

At best ours is not an easy fight, nor a short one. We so easily forget the struggle it must take to win a place in the curriculum; to force aside other courses that have been developed for years and that have been adapted to the schools, having teachers well equipped with knowledge and the best avenues of approach to

the student. We have not the guiding stones of others' mistakes and successes to direct us in the best line of effort. We are floundering for suitable texts, definite laboratory and plot manuals, satisfactorily equipped teachers, and even facilities for training our secondary school instructors. Our struggle is that of blazing the trail. Is it any wonder that we sometimes find ourselves in a blind alley and need to retrace our steps? Fortunate are we if, once in a while, we see a glimmer of light through the jungle in which we are struggling. As a teacher looks back over a year's work, surely he sees where definite mistakes were made; where difficulties were left unsolved; where vital things were left undone. But these things are our stepping-stones towards success. I really feel no other course in the curriculum, and the writer has taught several, demands, at the present time, more vital strength of a teacher, than does agriculture. Pioneers in any line have always suffered and toiled for the cause in which they struggled. And let me say here, when you work agriculture around any other center than practical plot work, you have severely weakened the foundation upon which your structure is built.

Outside of a large city, I claim plot work is impossible in no school, if you have the man to push the proposition through. You may supplement pot cultures and laboratory experiments for field work, and well, but you can see for yourself the handicap under which you labor. I appreciate the excuses you present. It is hard to get all of a class to work out of doors effectively; hard to get tools cleaned off and put away as they should be; hard to counteract the influence of the fellow in the class who has no purpose, and doesn't care to learn; hard to get the quality of work you desire in the field, even work hired done needs the closest of supervision. These things sometimes tax the instructor to the utmost. He certainly needs the coöperation with other schools, to feel that he is not alone in the fight, and even then, he cannot stand the strain unless, once in a while at least, he gets next to the boy's heart and feels the throb of love that must be the impelling force of every real teacher.

May we not then, in a definite way, during the following year, work together more earnestly, taking for our foundation the outdoor work, the practical through which the theoretical may find its largest fulfillment, and thus throughout our state, build up secondary school agricultural departments of which we may be justly proud.

PROBLEM DEPARTMENT.

By E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

282. *Proposed by Ruby Albert, Denver, Colo.*

Solve by quadratics:

$$3xy-4x-4y=0 \qquad (1)$$
$$x^2+y^2+x+y-26=0 \qquad (2)$$

I. *Solution by R. M. Mathews, Chicago, Ill., and Letetia R. Odell, Denver, Colo.*

$$3xy-4x-4y=0. \qquad (1)$$
$$x^2+y^2+x+y-26=0. \qquad (2)$$

Each equation is symmetrical with regard to x and y.

Put $x=u+v$, $y=u-v$.

Then (1) becomes $3u^2-8u-3v^2=0$, (3)

and (2) becomes $u^2+u+v^2=13$,

or $3u^2+3u+3v^2=39$. (4)

Adding (3) and (4), and simplifying we have:

$$6u^2-5u-39=0,$$

whence $u=3, -\frac{13}{6}$.

When $u=3$, $v=\pm 1$; and for $u=3$, $v=1$, for $u=3$, $v=-1$

$x=4$, $y=2$; $x=2$, $y=4$.

When $u=-\frac{13}{6}$, $v=\pm\frac{1}{6}\sqrt{377}$; and so $x=\dfrac{-13\pm\sqrt{377}}{6}$

$$y=\frac{-13\mp\sqrt{377}}{6}.$$

II. *Solution by L. L. Harding, Suffield, Conn., and Effie Morse, Compton, Cal.*

Multiply eq. (1) by 6 and eq. (2) by 9 and add $9(x+y)^2-15(x+y)-234=0$.

$\therefore x+y=6$ or $-\frac{13}{3}$.

Substitute $x+y=6$ in above equations and obtain $xy=8$ and $x^2+y^2=20$. Whence $x=4$ or 2, $y=2$ or 4.

Substitute $x+y=-\frac{13}{3}$, and obtain

$xy=-\frac{53}{9}$ and $x^2+y^2=\frac{97}{9}$. Whence $x=\frac{1}{6}[-13\pm\sqrt{377}]$,

$y=\frac{1}{6}[-13\mp\sqrt{377}]$.

283. *Selected.*

For what values of x is

(*a*) $\dfrac{a+x}{a-x}+\dfrac{a-x}{a+x}$ a minimum;

(*b*) $(x^2+2x+1)(7-x^2-2x)$ a maximum.

I. Solution by W. H. Zeigel, Kirksville, Mo., and F. Eugene Seymour, Trenton, N. J.

Since in all cases

$$(x+y)^2 = (x-y)^2 + 4xy$$

we have the following principles:

(a) If the product of two variables be constant, their sum is a minimum when they are equal.

(b) If the sum of two variables be constant, their product is a maximum when they are equal.

Hence $\frac{a+x}{a-x} + \frac{a-x}{a+x}$ is a minimum when

$\frac{a+x}{a-x} = \frac{a-x}{a+x}$, or when $x=0$.

Also, $(x^2+2x+1)(7-x^2-2x)$ is a maximum when

$x^2+2x+1=7-x^2-2x$, or when $x=1$ or -3.

II. *Solution by A. M. Harding, Fayetteville, Ark., and Nelson L. Roray, Metuchen, N. J.*

(a) Let $y = \frac{a+x}{a-x} + \frac{a-x}{a+x} = 2\left[1 + \frac{2x^2}{a^2-x^2}\right]$.

Then y has a minimum 2 when $x=0$, if we assume $-a<x<a$. Otherwise there is no minimum value.

(b) $(x^2+2x+1)(7-x^2-2x) = (x+1)^2[8-(x+1)^2] =$
$8(x+1)^2-(x+1)^4=16-[4-(x+1)^2]^2$

Hence its maximum value is 16, and it takes this value when $4-(x+1)^2=0$; *i. e.* when $x=1$ or -3.

III. *Solution by Julia M. Bligh, Batavia, N. Y.*

(a) $\frac{a+x}{a-x} = 1 + \frac{2}{a}x + \frac{2}{a^2}x^2 \ldots\ldots + \frac{2}{a^n}x^n.$

$\frac{a-x}{a+x} = 1 - \frac{2}{a}x + \frac{2}{a^2}x^2 \ldots\ldots \pm \frac{2}{a^n}x^n.$

Adding,

$$\frac{a+x}{a-x} + \frac{a-x}{a+x} = 2\left(1 + \frac{2}{a^2}x + \frac{2}{a^4}x^4 \ldots\ldots + \frac{2}{a^n}x^n\right).$$

Since only even powers of x occur in this series, the terms are all positive whether x is positive or negative. Hence $x = 0$ gives the minimum value of $f(x)$.

(b) If $f(x)$ is the product of two variable factors whose sum is constant, the square of half this sum is a maximum for $f(x)$.

$\therefore (x^2+2x+1)(7-x^2-2x)=16$

$\therefore x=1$, or -3 are the values of x for which $f(x)$ is a maximum.

Geometry.

284. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

Given the three diagonals of an inscriptible quadrilateral, to construct the quadrilateral.

If the internal diagonals are 10 and 12 and the external is 20, what are the lengths of the sides?

No solution received.

NOTE.—It is assumed that the radius of the circumcircle is given. In the numerical example let $r = 7$.—EDITOR.

285. *Proposed by D. A. Lehman, Goshen, Ind.*

Prove that the dihedral angle of a regular octahedron is the supplement of the dihedral angle of a regular tetrahedron.

Solution by R. M. Mathews, Chicago, Ill., and H. G. McCann, Boston, Mass.

It is easy to see that if the mid-point of each edge of a regular tetrahedron be joined to the mid-points of edges on adjacent faces, the joining lines will determine a regular octohedron.

Let V_1, V_2, V_3, V_4 be the vertices of a regular tetrahedron; K the mid-point of edge V_1V_2, L of V_1V_4, M of V_2V_4, and O of V_1V_3. Evidently, $V_1 - V_2\ V_4 - V_3$ is a dihedral angle of the tetrahedron, and O—KL—M is a dihedral angle of the octahedron. But the planes of these angles are parallel right to left and left to right, hence the angles are supplementary.

Remark. This theorem can be generalized as follows:

For each class of similar tetrahedra there exists a class of similar octahedra such that the dihedral angles at opposite edges of each octahedron are equal to each other and each is supplementary to a corresponding dihedral angle of any one of the tetrahedra.

The method of proof is exactly parallel to that given above.

286. *Proposed by H. H. Downing, Lexington, Ky.*

Prove:

(*a*) The sum of the squares of the lines drawn from any point of a circle to the angular points of a regular inscribed polygon of n sides is equal to $2nR^2$.

(*b*) The sum of the squares of all the lines of connection of the angular points of a regular polygon of n sides, inscribed in a circle of radius R, is n^2R^2.

Solution by Orville Price, Denver, Colo.

(*a*) Given the regular inscribed *n-gon* A B C D...., also P any point of circle. Denote the perpendiculars from the vertices A, B, C, D,.... on the tangent at P by p_1, p_2, p_3, p_4...., and the radius of the circle by R.

Then clearly

$$AP^2 = p_1 \cdot 2R,$$
$$BP^2 = p_2 \cdot 2R,$$
$$CP^2 = p_3 \cdot 2R, \text{ etc.}$$

Adding,

$$(p_1 + p_2 + p_3 + \ldots\ldots)\,2R = AP^2 + BP^2 + CP^2 + \ldots\ldots$$

Since the sum of the perpendiculars from the angular points of an inscribed regular polygon of n sides upon any line equals n times the perpendicular from the center on the same line,

$$p_1 + p_2 + p_3 + \ldots\ldots p_n = nR.$$
$$\therefore\ 2nR^2 = AP^2 + BP^2 + CP^2 + \ldots\ldots$$

(*b*) The sum of the squares of the lines joining any one vertex to all the others is $2nR^2$ as proved above. Then for n vertices we would have $2n^2R^2$. But in this way we have counted each line twice. Hence the result is n^2R^2.

CREDIT FOR SOLUTIONS RECEIVED.

270. James S. Elston, (2 solutions). (2)
272. James S. Elston. (1)
276. Julia M. Bligh, James S. Elston. (2)
278. J. L. Riley. (1)

279. James S. Elston. (1)

282. Gretchen F. Barr, Eugene M. Berry, T. M. Blakslee, Julia M. Bligh, John H. Bortz, W. S. Cawthon, James S. Elston, M. E. Gaskill, John Gaub, A. Gérardin, A. M. Harding, L. L. Harding, S. G. Johndroe, R. M. Matthews, H. G. McCann, Russell N. McKenzie, F. C. Mitchell, Effie Morse, Letetia R. Odell (2 solutions), C. A. Perrigo, Aaron Prussian (2 solutions), J. L. Riley, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, G. Sergent, Miriam I. Sheldon, F. Eugene Seymour, Montgomery R. Smith, C. H. Stoutenburgh, G. J. Van Buren, I. N. Warner, W. H. Zeigel. (36)

283. A. M. Harding, L. L. Harding, R. M. Mathews, Letetia R. Odell, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, F. E. Seymour, C. H. Stoutenburgh (2 solutions), W. H. Zeigel (2 solutions). (12)

285. Eugene M. Berry, Julia M. Bligh, R. M. Mathews, H. G. McCann, Nelson L. Roray, G. Sergent, E. M. Starr, F. E. Seymour. (8)

286. Julia M. Bligh, A. M. Harding, R. M. Mathews, Nelson L. Roray, Elmer Schuyler, F. Eugene Seymour.

Total number of solutions, 69.

PROBLEMS FOR SOLUTION.

Algebra.

297. *Proposed by Daniel Kreth, Oxford, Iowa.*

In what time will the compound interest on any principal at 4% equal the simple interest at 6%?

298. *Proposed by J. L. Orr, Birmingham, Ala.*

A man, standing on the rear end of a moving train, counts rail joints. When will the number of seconds or this count equal the speed of the train in miles per hour?

299. *Proposed by Henry A. Levy, Houghton, Mich.*

Find the value of the undetermined coefficients in the expansion:

$$\frac{(41)^5}{n^5(n+1)^5\ldots(n+4)^5} = \frac{1}{n^5} - \frac{64}{(n+1)^5} + \frac{216}{(n+2)^5} - \frac{64}{(n+3)^5} + \frac{1}{(n+4)^5}$$

$$+ \frac{A}{n(n+1)\ldots(n+4)} + \frac{B}{n(n+1)\ldots(n+3)} - \frac{90}{n(n+1)(n+2)} + \frac{C}{n^3(n+1)^3\ldots(n+4)^3}$$

$$+ \frac{D}{n^3(n+1)^3\ldots(n+3)^3} + \frac{E}{n^3(n+1)^3(n+2)^3} + \frac{F}{n^3(n+1)^3} + \frac{G}{n^3(n+4)^3}.$$

Geometry.

300. *Proposed by C. H. Stoutenburgh, Trenton, N. J.*

From a square construct a regular octagon by cutting off each corner. Prove the construction.

301. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Solve without the use of trigonometric functions: The distance between the feet of two towers standing on a horizontal plane is $2a$. The angles of elevation of their tops from the mid-point of $2a$ are complementary. The angle of the elevation of the top of the higher from the foot of the lower is double that of the top of the lower from the foot of the higher. Find the height of each tower.

302. *Proposed by Norman Anning, North Bend, B. C.*

With a given number of trees per acre of orchard, how much farther apart may they be placed by using the equilateral triangular plan instead of the square?

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science *are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

Proposed by A. Bjorkland, The High School, Appleton, Wis.

Answer Serially Numbered Questions.

[These questions were given at the end of the first semester and constituted the final for the short course in physics.]

Physics Semester Final.

1. How is the pull of the earth changed as you go toward the North Pole? Why? What effect will this have on the period of a pendulum? What other condition at the North Pole is apt to change the period of a pendulum? Why?

2. How can you find the resultant on a wagon pulled by two horses, the one being hitched ahead of the other? How can you find the resultant if the two are hitched side by side but pulling at an angle of 60 degrees? Illustrate.

77. Explain how to get the total weight of a boat; what dimensions would you want, and how would you compute the weight from these?

78. A person pulls with a 100-pound force through a distance of 10 feet on the rope of a pulley system, lifting a 400-pound weight 2 feet. Find the mechanical advantage and the efficiency of the pulley system. Theoretically, what should be the value of the efficiency?

Answer any four of the remaining questions.

5. Define: calorie; specific heat; mechanical advantage (real); mechanical equivalent of heat; conduction of heat.

6. What is meant by humidity? What will be the effect on the humidity when the cold outdoor air is brought in and heated?

7. Why is the handle of a coffee pot often made of wood while the bottom is made of copper?

8. Having a magnetic compass, explain how you can tell whether an electric cell is able to give a current. Using the same compass how can you tell which of two cells is able to give the greater current?

79. Compute the cost per hour of an electric heater using 10 amperes at 110-volts pressure, the price of electrical energy being 12 cents per kilowatt-hour.

10. State Ohm's law. State the substance of Lenz's law.

80. *Proposed by Tom Anderson, Cleveland, Ohio.*

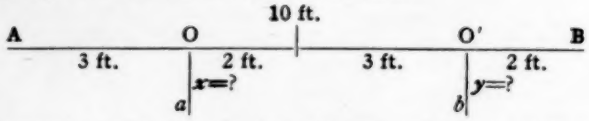
What weight of Mn_3O_4 corresponds to 1 gm. $Mn_2P_2O_7$?

Solutions and Answers.

A uniform beam AB, 10 feet long and weighing 50 pounds, rests horizontal on two supports, one of which is 3 feet and the other 8 feet from A.

(a) What force is exerted on each support? (b) Suppose that a weight of 20 pounds is hung from the end A, what is now the force on each of the supports?

Solution by P. A. Smoll, Three Rivers, Mich.



This solution is made by the law of moments, which states that the algebraic sum of all the moments of a body are = 0 if the body is at rest. This body is at rest, therefore the law applies. Let x = load on a, and y = load on b.

For convenience let the clockwise moments be + and counter clockwise —. It is evident that there is a + and — moment about each point O and O'. By the law of moments the sum of these for each, O and O' = 0.

Then 2×50 = the + moment about O in which 50 is the weight of the beam acting at the center of gravity or 2 feet from O.

And $5 \times y$ = the — moment about O in which the force is the reaction of the support b against its load y. But action and reaction are equal so the upward force of b may be substituted by y.

Now $(2\times50)-(5\times y)=0$, or the sum of the moments about O.
$5y=100$ and $y=20$.

In the same way
$5x-(3\times50)=0$, or the sum of the moments about O',
and $5x=150$, or $x=30$.

Therefore the force exerted on a = 30 lbs., and on b = 20 lbs. If a 20-lb. weight is placed on the end A it will create another (—) moment about the points O and O' and these will then have to be included in the algebraic summation of moments as follows:

(1) $(20\times50)-(3\times20)-(5\times y)=0$ or the algebraic sum of the moments about O.

(2) $(5\times x)-(2\times50)-(8\times20)=0$ or the algebraic sum of the moments about O'.

Solving (1) $5y=40$
$y=8$
" (2) $5x=310$
$x=62$.

Therefore the forces exerted on supports a and b under the second condition are 62 lbs. and 8 lbs. respectively.

PHYSICS SUGGESTIONS.

By W. E. Wing,
Deering High School, Portland, Maine.

I notice in the March issue of School Science and Mathematics that you want information on what teachers are doing. So do I.

Although no claim is made as to new methods, originality, or startling results, I am going to tell you a few physical experiments performed at Deering High School, hoping that they may be of interest

to others; and I hope every teacher will respond to your call for information. In this way "our" magazine can render the highest possible service.

I have discarded all laboratory manuals with the following results: students are more resourceful; notebooks show originality, and are not painfully stereotyped, with the words data, method, apparatus, and conclusion on every page.

I require a notebook to be neatly kept and methodical. Above all that notebook must be the record of the student's own work, even if it is not so showy. This type of notebook cannot be obtained by using any laboratory manual or loose leaf directions that I have ever seen.

The only excuse that I have ever heard offered for using a manual is that it saves time.

Without the manual, it is very slow work at first, but when students once understand how to go at a given task, they more than make up for lost time.

At the present writing, I find my beginners' class in physics just three weeks in advance of any of my classes of previous years where the manual was used.

I am through paying fabulous prices for fragile toys to use in the laboratory. With a very few exceptions, I prefer to have the real article, rather than the working model. I would rather have one set of blocks and tackle with a half inch rope than thirty sets of miniature pulleys. Anything diminutive savors of the toy, and consequently loses its impressiveness as being real.

Not only do I believe in using *real* machinery, but I want real commercial problems. Since the high cost of living is a live topic with everyone, I make the "cost" the chief object of a number of experiments. The Gas Company gave us a condemned meter, and loaned us a new meter and a gas range.

We learned how to read the meter, then took the old one apart to see how it was constructed. At present we are finding out how much it costs to burn gas for cooking, as well as for lighting. Incidentally the girls are computing the cost of producing a loaf of bread, to see whether it is cheaper to make bread or to buy it; whether it is cheaper to burn coal or gas.

The Electric Light Co. gave us two condemned watt-meters and loaned us a new one. The advantage of having the real meters is obvious.

We have a number of volt meters and ammeters (commercial types), and here I wish to express my satisfaction with the new portable type of Weston A. C. ammeters. These instruments may be used with either D. C. or A. C., and of course are absolutely reliable and not expensive, if bought direct for school use.

Some very interesting experiments can be performed with nichrome wire. This wire is an alloy of nickel and chromium and has the highest known resistance. It is used commercially in electric bread toasters and is excellent to use for volt-meter-ammeter method of finding resistance, and to show the heating effect of electric current.

I know of no experiment which my pupils enjoy more than measuring the current used by all kinds of electric lamps, at the same time measuring the candle power, computing cost per candle power hour and comparing the results.

Getting the brake H. P. of an electric motor, finding the efficiency and reckoning the cost of running, is another popular experiment. Meas-

uring current used by electric bread toasters and flat irons, and computing the cost of running is also good. Comparing the cost of operating electric irons with a gas iron, tungsten lamps with Welsbach mantels is also worth while.

The following will give an idea of the physics examination given in February: Each pupil was required to choose some machine in which he was particularly interested; make digrams of it, observe applications of physical principles and reckon the mechanical advantage of cogwheels and pulleys. Three weeks were given for preparation. Then a preliminary conference was held with each student, suggestions were offered, and hints as to what would be expected at the final conference. After the preliminary conference the explanations and diagrams were carefully written in a blue book and passed in. At the final conference at least ten minutes were spent with each student.

The only provision was that diagrams and figures must be obtained from actual machines.

The results were such that similar examination will be a yearly feature in the beginners' physics course. Here are a few of the machines selected by the pupils: gasoline engine; automobile transmissions and differentials; camera; stereopticon; meat grinder; sewing machine; drill; molder; planer; lathe; gas meter; steam engine; block-signal system on the Boston & Maine R. R.; heating plant; telegraph, duplex and quadruplex; marine engine; lawn mower.

Each member of the advanced Physics class is working on some commercial electrical appliance which necessitates a trip to some office or factory. After the material gathered has been carefully written in detail, the student will give a talk to the class, and by means of diagrams he will explain its use, operation, etc., and when possible give the history of its development. Here are a few of the assignments: Automobile ignition systems; wireless outfit; A. C. dynamos; D. C. dynamos; automatic elevator; telephone switchboard; watt meter and automatic telephone.

One week is allowed for preparation and it will take about a week to take up the different subjects.

The articles by Professor Jameson in our March and April numbers are apropos, and point out the way for physics teachers. The same opportunity is open to all science teachers. All of us need "to come down to earth," to make our work *real*. There is nothing so unfruitful of results as to place a piece of insignificant apparatus in the hands of the student, only to tell him after he has worked diligently for an hour that "if the apparatus were all right he ought to get such and such a result."

I hope that science teachers in other parts of the country will tell what they are doing for *real* experiments.

A CHART FOR PHYSICS.

By John Zimmerman,
Dubuque German College, Dubuque, Ia.

In my work with elementary physics classes, in places having limited supplies of apparatus and no projecting lantern, I have frequently felt the need of a chart of diagrams, giving some of the text-book figures, together with additional ones of illustrative and educational value.

These diagrams should be large and clear, so that anything pointed out on them could be seen from the farther end of a schoolroom of ordinary

size. If some of them were exact reproductions of text figures they would have extra value in connection with that particular text. Many figures of any one of the modern physics text-books can serve as an excellent basis for recitation. The teacher, as a rule, cannot take the time necessary for the reproduction of these figures on the blackboard, and if the books are used for this purpose several obstacles present themselves; the text is in sight and the recitation for that reason develops less independence, the instructor is not always sure that all members of the class are looking at the right part of the figure, he cannot explain a particular feature as well as when his explanation can be emphasized by the end of a pointer, in transferring the attention of the class from one part to another a verbal transition will have to be constructed, which does not add to the progress of the recitation and could be eliminated with the use of a chart and a pointer.

Figures in addition to those found in the text used, illustrating scientific features and applications of modern mechanics and industry as well as historical developments of scientific principles, would also be very valuable for class illustrations from a chart. We are not yet making the largest and best use of this most valuable means of instruction, and cannot do so without adequate charts for this purpose.

I have been wondering how many of my fellow teachers are so situated that they have felt the need of such a chart as I have, and in how many more a desire for one could be aroused by their own consideration of the possibilities it would offer.

I have communicated some of these ideas to two publishing houses at different times. Each one, however, seems to think that the publication of such a chart would not secure for them ordinary financial returns.

Could there not be an exchange of ideas on this proposition by teachers situated similarly to myself? Could there not be, in some way, an expression of the wishes of those interested in this move, which might lead to a more definite formulation of plans, and ultimately to a realization of advancement in this phase of educational work? If I could do anything further in this matter beyond advancing the mere suggestion herewith made, it would be a source of great pleasure to me.

ANTARCTICA—TWICE AS LARGE AS EUROPE.

The Antarctic continent has been estimated to be at least twice as large as Europe. The evidence of paleontology is to the effect that Antarctica was once connected with the more northern lands, at least with South America; and that in prehistoric ages some tremendous convulsion of the earth's crust resulted in the sinking of the "submarine" floor, until in some places it is now 4,000 fathoms, or more than four miles below the surface. All around the great land mass of this continent there is a deep ocean bed cutting it off from every other land of the earth, and setting it apart as a region more unlike the rest of the globe than any other continent or island. Explorations have proven that in times before the advent of man upon the earth, this most southern land had a temperate, or even a warmer climate. There are fossils, both animal and vegetable, which indicate this. The formation of the rocks in Antarctica also is of volcanic origin and volcanic activity, notably in the case of Mount Erebus, which is not yet extinct. A vast mountain range, perhaps at one time a continuation of the Andes, exists in Antarctica.—*American Review of Reviews.*

REWARDS FOR DISCOVERY OF UNDISTURBED NESTINGS OF PASSENGER PIGEONS ARE RENEWED.

It has finally been decided to renew the offers of rewards for report of undisturbed nestings of passenger pigeons for one more season—until October 31, 1912.

Not even a probable nesting has been reported for either 1910 or 1911. All reports sent in have proved to be for other species of pigeon or dove —of band-tailed, viosca, red-billed, or white-winged pigeons, from the Rocky Mountain and Pacific Coast region; or of the mourning dove from Eastern North America.

In addition to the above, all passenger pigeons reported killed during this time, as far as it has been possible to ascertain the truth, have proved to be some other bird. Not so much as a feather of tangible evidence has come in that the passenger pigeon exists in the wild state during the two years of active search.

The rewards are renewed because a number of apparently reliable observers have reported seeing passenger pigeons during 1911. These reports have come in from Iowa, Illinois, Wisconsin, Michigan, Pennsylvania, and New York. Even if all of these reports are true, it is evident that very few of the birds still survive. If a few scattered flocks are left, the experience of the two seasons past proves that discovery of their nesting places is a matter of extreme difficulty. This means that more strenuous and persistent methods must be adopted, and more concerted effort be secured if the search of this third and last season is likely to be successful.

It may be that the few surviving pigeons are nesting in sections uninhabited or difficult of access. If this is true, plotting the course of their migration flights, or of their feeding flights, may point to their probable nesting places. If all who see pigeons this spring will report immediately (giving in the first letter, please, exactly) DATE and HOUR, NUMBER IN FLOCK and DIRECTION OF FLIGHT, it may be possible, by convergence of testimony, to locate the nestings. This seems to be our last and only hope.

May this third year prove more fortunate in our efforts to save to America and to the world the finest race of pigeons ever evolved.

Please secure publication of this statement and of the enclosed list of rewards in all possible local papers.

LISTS OF REWARDS WITH CONDITIONS GOVERNING THEM.

ONE THOUSAND DOLLARS ($1,000) REWARD

For first information, *exclusive and confidential*, of the location of a nesting pair of colony or passenger pigeons, anywhere in North America; when properly confirmed and if found by confirming party with parent birds and eggs or young UNDISTURBED:

Colonel Anthony R. Kuser will pay a reward of $300
John E. Thayer will pay a reward of $700

For first nesting discovered thereafter in the following states will be paid by:

John Burroughs, New York $100
A. B. F. Kinney, Massachusetts 100
Anonymous, Massachusetts, 2d find 100
Allan B. Miller, for 1st nesting found in Worcester Co., Mass..... 20
Edward Avis, Connecticut 100
Harry S. Hathaway, Rhode Island 100

Worthington Society, New Jersey	10
John Dryden Kuser, for 2d nesting found in New Jersey	10
Henry W. Shoemaker, Pennsylvania, $200. (Adds $25 if nest is protected)	225
W. B. Mershon, Michigan	100
R. W. Mathews, Minnesota	100
Ruthevan Deane, Illinois	50
John E. Thayer, Maine, New Hampshire, Vermont, Ontario, Wisconsin, $100 each	500
John Lewis Childs, for first three nestings not entitled to any of the above rewards, $200 each	600

The purpose of these offers is to secure an intelligent search of the American continent for breeding pigeons in the hope that, if found, the species may be saved from extermination.

All above rewards are offered solely and only for information of location of undisturbed nestings. We do not desire possession of any birds, alive or dead, but are working solely to save the free, wild pigeon.

To insure intelligence and good faith informants of nestings are advised to enclose or agree to forfeit at least $5 in case they have failed to identify the birds correctly. This is only fair, since the amount may cover but a small part of the costs occasioned by a false report. The money will be immediately returned, if the birds are found to be passenger pigeons (Ectopistes migratorius). In the case of nesting pigeons, there can be no excuse for sending in false reports. *Disregard all nests on the ground. The wild pigeon always nests in trees, generally ten feet or more from the ground.*

Priority of claim will be decided by time of receipt at post or telegraph office. Rewards will be equally divided, if two or more letters or messages bear record of same date and hour. All nestings within one mile of one another will be counted as one colony.

Please report all pigeons seen, giving *exactly date, hour, number in flock, direction of flight.* Unless absolutely certain that you know the band-tailed, viosca, and red-billed pigeons, do *not* report that you have seen the passenger pigeon in the Rocky Mountains or Pacific Coast region, from British Columbia to Mexico.

As soon as a pigeon nesting is surely identified write the undersigned, who will arrange for confirming party and for payment of the reward. All rewards not claimed by October 31, 1912, will be withdrawn.

Signed, C. F. HODGE,
Clark University, Worcester, Mass.

For descriptive leaflets with colored pictures of the pigeons and mourning dove, enclose six cents, stamps, to Chas. K. Reed, Worcester, Mass.

NOTE:—*You are millions to one, already busy man. Please do not write Dr. Hodge for INFORMATION. $1.00 pays the postage on only 5,000 letters.*

THE DISCOVERER OF THE SOUTH POLE.

Roald Amundsen is a typical Viking, in spirit, if not in physical appearance. His whole career has been characterized by that indomitable courage, perseverance, and patience that is typical of the fierce sea rovers of old. It may be said that while, to a certain extent, good luck attended his expedition, as good luck attended that of Peary, in both cases it was

the good fortune that always accompanies the strong and the brave. Both Peary and Amundsen did more than discover the Poles. They besieged them, and the mysteries at last were unveiled to those who had the will and patience, the skill and the perseverance to dominate the situation.

For many years Captain Amundsen has been considered one of the most daring and skillful of Polar explorers. He has been a sailor from his youth. At the age of twenty-five he sailed with the "Belgica" expedition to the Antarctic. On his return he decided to devote the rest of his life, if need be, to the endeavor to discover the famous Northwest Passage which had been sought for more than three centuries by such daring sea spirits as Frobisher, Cabot, and Franklin. For two years Amundsen studied magnetism and meteorology. Then in June, 1903, in the "Gjoa," he set sail from Christiania. After three years' wanderings through the ice, rocks, and unknown lands of the Northwest, he eventually brought his little vessel through Behring Strait, and thus for the first time navigated the Northwest Passage. During this voyage he determined exactly the position of the magnetic pole.

Amundsen is forty years old, a strong-willed character of scientific equipment and modest as to his own achievements. He speaks highly of the work of the Japanese expedition, with which he came into contact on the trip, and refers respectfully and sympathetically to the expedition of Captain Robert Scott, the English explorer who left New Zealand on the other side of the globe from Captain Amundsen at about the same time. The equipment of Captain Scott's party and his own qualifications, aided as they have been by the advice and experience of Sir Ernest Shackleton, were believed to have given him even a better start in the search for the Pole than his Norwegian rival. Very soon after the start of these two men, the world began to refer to their efforts as a race. Scott's party intended to be more deliberate in its work, making scientific investigations and explorations of a more extended sort than Amundsen had set himself to do. It was expected that Scott would attain the Pole at about the time Amundsen actually reached it. The Norwegian, however, saw nothing of his English rival, and the latter had not been heard from up to the middle of last month. Amundsen admitted that Scott might have been at the Pole before his own party, and might have left a memorial that had possibly been swept away by storms. His own base, he said, was 500 miles from that of the British party. "I sincerely hope," he told the newspaper reporters, "that Scott's expedition was successful."—*American Review of Reviews.*

ASSOCIATION OF MATHEMATICS TEACHERS IN NEW ENGLAND.

The midwinter meeting of this association was held at Wilson Hall, Brown University, Providence, R. I., on February 2, 1912, at 2 P. M.

Professor R. C. Archibald of Brown University delivered an address on "Mathematical Instruction and the Professors of Mathematics in the French Lycées," and Mr. A. H. Morrison of the Mechanic Arts High School, Boston, spoke on "Mathematics in Elementary Schools."

The two papers were discussed for a half hour by the members present.

H. D. GAYLORD, *Secretary.*

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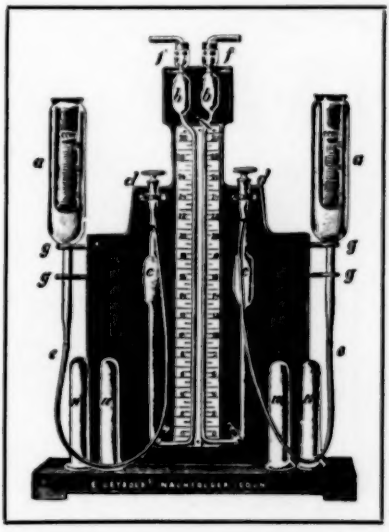

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MATHEMATICS SECTION OF THE CALIFORNIA TEACHERS' ASSOCIATION.

The mathematics section of the California Teachers' Association (Bay Section) met at Stockton on December 28, with the President in the chair. In the absence of the Secretary, Principal Herbert Kittredge of Antioch was appointed in his place.

The feature of the meeting was a very able paper sent by Professor A. W. Whitney of the University of California. Under the title of "Constructive Suggestions for High School Mathematics" he treated many of the fundamental problems that confront the teacher and pupil, and, in a most entertaining and illuminating way, built up a philosophical system of practical concrete teaching. A brief extract from his paper will reveal the keynote:

"Mathematics, most of it, was not spun in its present form; it was the clothing of lusty physical facts. But when it was found that the same clothing could be worn by many facts and finally that it could even stand alone, it, with its fellows, was set up in an armory. But it takes a great deal of imagination to feel the glory of knighthood and battle through looking at armor; it is more likely to seem rusty and creaking.

"It is obvious what ought to be done—in our teaching we must give mathematics a body. Throw up the windows and let in a fact or two—bare facts; turn them over, enjoy the mystery of their being, let the senses feast on their fatness, dance about them for pure joy of their wholesomeness and then finally fit them out decently and becomingly with a mathematical dress."

Miss T. Brookman of the Berkeley High School followed with "The Problems of Elementary Algebra." Her talk was replete with helpful bits of her experience in her attempts to work out a successful mathematics course in the six year high school. She illustrated some of her points by exhibits of the work of pupils on practical problems, one of which, a graph of the speed of trains on one of the main lines leading out from San Francisco, was especially good. She showed a simple device of geared and belted wheels to impress the fundamentals of ratios, direct and inverse, and developed a very simple scheme for teaching variation and proportion.

Her enthusiasm as she told of the interest her pupils took in finding practical problems about the threads of screws, sizes of bolt heads under the U. S. standards, interpreting formulas, etc., etc., betrayed the secret of her successful teaching. An animated discussion followed, during which Miss Brookman made "the concrete way" seem not only rational, but easy.

The session was closed with a brief discussion of "The New Geometry Syllabus," led by Principal Lewis B. Avery of the San Jose High School. The salient points of the scheme were emphasized, and there seemed to be a general concurrence in the conclusions of the committee.

The following officers were elected for the coming year:

President, Miss May V. Haworth, High School, Alameda.
Vice-President, Principal O. A. Johnson, High School, San Mateo.
Secretary, Mr. D. W. Lindsay, High School, Mountain View.
Member of Executive Committee, Dr. A. W. Stamper, State Normal School, Chico.

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ARTICLES IN CURRENT PERIODICALS.

American Forestry for March: "The New Italian Forestry Policy," Dr. Guido A. R. Borghesani, four illustrations; "The Great American Desert," C. J. Blanchard, five illustrations; "Investigating Forest Insects," Dr. L. O. Howard; "Timber Sales on the Plumas National Forest, California," Rufus S. Maddox, four illustrations; "Progress in Forestry Planting in the Nebraska Sand Hills," four illustrations; "The Chestnut Blight Campaign," Percival S. Ridsdale; "Forest School of the University of Idaho," three illustrations.

Catholic Educational Review for March: "Higher Education in South America," Charles Warren Currier; "A College Course in Bibliography," Joseph Schneider; "The Empirical Movement in Education," Thomas V. Moore; "The Danger of Early Specialization," Herbert F. Wright.

Educational Psychology for March: "The House of Childhood": A New Primary Method, Howard C. Warren; "A Tentative Revision and Extension of the Binet-Simon Measuring Scale of Intelligence," Part II, Supplementary Tests, 1. Generalization Test: Interpretation of Fables, Lewis M. Terman and H. G. Childs; "Qualities of Merit in Secondary School Teachers," Arthur Clifton Boyce.

Nature Study Review for March: "Pedagogy of Secondary School Agriculture," L. D. Coffman; "Nature-Study and the 'Garbage Barrel,'" Ernest B. Babcock; "Varieties of Radishes," Emily Benoit; "Suggestions for Crayfish Study," Margaret W. Taggart; "Eugenics," H. H. Laughlin; "Dental Hygiene," Hyman Cohen, M.D.

Physical Review for February: "Reaction Effects Produced by the Discharge of Electricity from Points in Gases and the Bearing of these Effects on the Theory of the Small Ion," Edward J. Moore; "The Magnetic Rotation and Ellipticity Produced by Mirrors of Massive Metals," Paul D. Foote; "A Study of the Reversible Pendulum." Part II. Experimental Verifications, John C. Shedd, J. A. and W. N. Birchby.

Popular Astronomy for April: "The Asteroid Problem," Joel H. Metcalf; "The Variable Stars," Fr. Argelander, Concluded; "Recent Researches as to the Systematic Motions of the Stars," Lewis Boss; "A Modern Look at the Universe," Henry Olerich; "A Question on the Capture Theory," N. W. Mumford; "The Reform of the Calendar," Ralph E. Wilson.

School Review for April: "The General-Science Course in the University High School," William Lewis Eikenberry; "A Course in Moral Education for the High School," Frank Chapman Sharp and Henry Neumann; "The Conference Hour in the Pittsburgh High Schools," Edward Rynearson.

School World for March: "Weather Study for Schools," W. Maclean Carey; "Combustion—The Phlogiston Theory," W. A. Witton; "The Use of Simple Models in the Teaching of Elementary Geometry," A. L. Fletcher; "Teachers' Views of Examiners' Reports on Local Examinations: Mathematics II," R. Wyke Bayliss.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht for February: "Ueber die Verwendung Mathematischer Originalwerke im Unterricht," Walter Mendelssohn; "Neue Ableitung des binomischen Satzes für beliebige reelle Exponenten," Dr. Ernst Eckhardt; "Schul-Mathematik in Tabellen," Professor K. Schmalz; "Zahlenrechnungen im Unterricht," A. Schülke; "Zur Reformbewegung auf den Gebiete des mathematischen und naturwissenschaftlichen Unterrichts," edited by Oberlehrer Dr. W. Lietzmann; "Zur Geometrographie," edited by K. Hagge.

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SYLLABUS IN CHEMISTRY.

The following letter represents a report in connection with the revision of the syllabus in chemistry of the College Entrance Board. The topics given in the various groups do not necessarily represent what the Committee considers desirable as a final syllabus, since the time at its disposal was not commensurate with the importance of the matter it was considering. The topics are presented rather as a definition of what is meant by the various groups, and with the idea of showing that elementary chemistry can be taught largely through its practical applications.

Mr. Robert W. Fuller,
Secretary of the Committee on the Revision of the College Entrance Syllabus in Chemistry.
Stuyvesant High School, New York City.

Dear Sir:

The Committee appointed by action of the Chemistry Teachers' Club (of New York and vicinity) to make recommendations to your Commission in connection with its revision of the existing syllabus, has entered upon its work with the following considerations in mind:

That the syllabus, while formulated primarily to represent the amount of knowledge necessary for college entrance, in practice does the even more important work of determining the nature of the course for the ninety per cent of pupils who never enter college;

That there is a very general feeling among secondary teachers that it is highly desirable to experiment with courses designed primarily for the benefit of the non-college entrance pupil; that, since it is often impossible to tell in advance what pupil is to enter college and what one is not, these experiments are practically impossible so long as there is a necessity of meeting a rigid type of college entrance paper.

The Committee, therefore, feeling that these difficulties are entitled to the very serious consideration of the Revision Committee, recommends a syllabus, or syllabuses, leading to a paper of the following type:

(a) The question paper would consist of two parts, Part I and Part II. Each candidate would answer Part I, choosing five questions from a total of six. These questions would require a knowledge of the more fundamental principles of elementary chemistry (pure chemistry) as indicated in the outline presented below.

(b) Part II would consist of three groups of questions, Group A, Group B, and Group C. Each of these groups would consist of six questions. Each candidate would answer five questions from Part II, choosing them either (1) entirely from one of the three groups, or (2) from not more than two of the groups.

Group A. Questions in this group would require a knowledge of relatively advanced theoretical and descriptive chemistry (pure chemistry), including simple, practical applications as indicated below.

Group B. This group would require a knowledge of industrial chemistry (the more important chemical manufacturing operations).

Group C. This group would require a knowledge of household chemistry. Tentative outlines are here presented for Part I, and for groups A and B and C in part II.

OUTLINES.

Part I. A study of such topics as chemical action, energy change (qualitatively) as a characteristic of chemical action, oxidation, reduc-

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Part II, Group A. Correction for gas volumes, law of multiple proportions, logical development of the atomic theory, Avogadro's hypothesis, derivation of hydrogen molecule as H_2, determination of molecular weights, derivation of formulas, electrolysis, theory of electrolytic dissociation and its application in explaining neutralization, hydrolysis and allied topics—mass action and chemical equilibrium in their simpler applications, bromine, iodine, phosphorus, silicon, potassium, sodium, calcium, zinc, magnesium, copper, silver, aluminium, lead, iron, carbon monoxide, ammonia, hydrogen sulphide. In the treatment of the above topics, considerations should be given to their more familiar applications, industrial and household.

Part II, Group B. Water for industrial purposes; manufacture of acids—sulphuric, hydrochloric, nitric and acetic; manufacture of alkalis—sodium hydroxide, calcium hydroxide, carbonates of sodium, lime; electrolysis as applied to electroplating and purification of metals; illuminants; fuels, solid, liquid and gaseous; furnaces, blast, reverberatory, electric, converter; metallurgy—iron, steel (open hearth and crucible), lead, aluminium; alloys; glass; ceramics; building matrials, mortar, cement, reënforced concrete; fertilizers—nitrogen compounds, phosphates; potassium salts; photography; organic compounds—soap, alcohol (grain and wood), fermented and distilled liquors, cane sugar, starch, glucose.

Part II, Group C. Air, combustion and ventilation; fuels—coals, charcoal, coke, kerosene, gasoline, coal gas, water gas; illuminants; stoves and furnaces (household); cooking utensils—metals and enamel ware; water—physical properties, drinking water purification, hard waters; soaps and washing powders, (oils, fats) laundry operations; other cleansing processes (for grease, rust, mildew, ink, etc.), fermentation, putrefaction, preservation; garbage and sewage disposal; disinfectants; foods: general (1) classes—proteins, carbohydrates, fats, mineral constitutents; (2) food values (dietetics), (3) cooking—roasting, broiling, stewing, etc., (4) digestion and absorption; (5) means of preserving, (6) testing for adulterants and preservatives; special (1) breads, flours, cereals, (baking powders), (2) eggs, (3) dairy products—milk, butter, cheese, (4) meats, (5) vegetables, (6) fruits; textiles—cotton, wool and silk with their manufactured products; artificial and imitation fibres, bleaching of cotton, wool, and straw, direct dyeing of cotton and wool.

Committee.

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Reprint of Vol. x, No. 1, of the Teachers College Record, January, 1909. 120 pages. Price, cloth bound, 75 cents; paper bound, 30 cents.

ARITHMETICAL ABILITIES AND SOME FACTORS DETERMINING THEM

By Cliff Winfield Stone, Ph. D.

Published as No. 19 of the Teachers College Contributions to Education, June, 1908. Cloth bound, 101 pages. Price, $1.00 postpaid.

A HISTORY OF SIXTEENTH CENTURY ARITHMETIC

By Lambert L. Jackson, Ph. D.

Published as No. 8 of the Teachers College Contributions to Education, 1906. Cloth bound, 261 pages. Price, $2.00 postpaid.

HISTORY OF TEACHING OF ELEMENTARY GEOMETRY

By Alva Walker Stamper, Ph. D.

Published as No. 23 of the Teachers College Contributions to Education, 1909. Cloth bound, 163 pages. Price, $1.50 postpaid. Paper, $1.15.

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BOOKS RECEIVED.

Elementary Plant Biology, by James E. Peabody, Morris High School, New York, and Arthur E. Hunt, Manual Training High School, Brooklyn. Pages xvi+207. 13x19 cm. Cloth, 1912. 75 cents net. The Macmillan Company, New York.

Who's Who in Science, by H. H. Stephenson, Lambeth, England. Pages xvi+323. 15x23 cm. Cloth, 1912. $2.00 net. The Macmillan Company, New York.

Applied Physics, by V. D. Hawkins, Technical High School, Cleveland. Pages ix+199. 11x20 cm. Cloth, 1912. Longmans, Green & Co., New York.

Carnegie Foundation for the Advancement of Teaching. Sixth Annual Report. Pages vi+154. 19x25 cm. Paper, 1911. 576 Fifth Avenue, New York City.

The Teaching of Primary Arithmetic, by Henry Suzzallo, Teachers College, Columbia University, Pages xi+124. 12x18 cm. Cloth, 1912. 60 cents. Houghton, Mifflin Company, Boston.

Earth Features and their Meaning, by William Herbert Hobbs, University of Michigan. Pages xxxix+506. 15x22 cm. Cloth, 1912. $3.00 net. The Macmillan Company, New York.

School Review Monographs, No. 11. 153 pages. 15x24 cm. 1912. Paper. 56 cents postpaid. University of Chicago Press.

BOOK REVIEWS.

New England Trees in Winter, by A. F. Blakeslee and C. D. Jarvis. Storrs Ag. Exp. Sta., Storrs, Conn. Bull. 69. 270 pages.

The book includes description and photographs of practically every native tree of New England. The descriptions are clear, definite, and untechnical. The photographs are remarkably good. The key appears to be well adapted to its purpose.

The authors used the proof of keys and descriptions in classes, revising wherever the pupils found serious difficulties. The method is good and if it had been applied in the past by other authors might have saved us from a multitude of half-baked floras and keys.

The teachers of New England and adjoining states are particularly indebted to the authors for this very efficient tool. Unfortunately the edition is limited, but it is understood that the work will soon be published in book form. W. L. E.

Laboratory Problems in Physics, by Franklin T. Jones, University School, Cleveland, and Robert R. Tatnall, Northwestern University. Pages ix+81. 13x19 cm. Cloth, 1912. Illustrated. 50 cents net. The Macmillan Company, New York.

A splendid little book gotten out primarily to accompany Crew & Jones' Elements of Physics. It may, however, be used with and secondary text in physics. It is written in clear language, easily understood by the pupil. It puts particular stress on the principle to be learned. The book shows the imprint of the authors' long experience in teaching physics. The practical application at the close of each experiment is a most valuable feature, the apparatus described and recommended is simple and of the standard variety. C. H. S.

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BOOK REVIEWS.

The Farm and Garden Blue-Book. By L. H. Bailey. Published by The Macmillan Company. 587 pages. $2.00 net. 1911.

This is the fourth writing of a book under this or a similar name by the same author. It is now entirely rewritten, and to many people will serve as a ready reference or source book in place of the larger and more expensive series—the cyclopedia of agriculture and horticulture. The book is a compendium of information upon the larger number of things concerning which farmers, gardeners and orchardists should know. It is a book of the greatest value for the frequent consultant, but not a book for the regular reader. It gathers into one set of covers a prodigious amount of data, secured from more elaborate works upon limited fields, from texts, bulletins and government reports, and above all from active first-hand experience with many of the problems that are covered. The amount and exactitude of details that are given, the charts and planting tables, planting schemes, guides for cultivation and care of plants and animals, for securing, mixing and applying fertilizers, for combating plant and animal diseases, for harvesting, grading and marketing plant and animal products, for greenhouse construction and management, for designing buildings and securing appropriate propelling power, all these but briefly suggest the informational and reference nature of the work. The value of this book is such as to guarantee more than the completion of a quarter of a century of usefulness to it and its predecessors, which made their first appearance in 1889. O. W. C.

PROPERTY RIGHTS VS. PUBLIC HEALTH.

A New York dealer was recently prosecuted for counterfeiting the trade-mark for Carter's Little Liver Pills and for selling goods bearing this counterfeit mark. He was found guilty, and, although it was the first offense, the court refused to impose a fine, but sentenced him to four months' imprisonment in the penitentiary at hard labor without the possibility of commutation for good behavior. Counterfeiting, of course, is a serious crime and as such should be punished. Nevertheless, there are more serious crimes, such, for instance, as adulterating foodstuffs, selling putrid material for good or dispensing dangerous, habit-forming drugs, like cocaine, in the shape of soft drinks. All these crimes are crimes against the person—against the public health—against the very lives of the people. Although the government officials have brought evidence sufficient to convict over 1,200 firms or individuals of violating the federal Food and Drugs Act, and although this act provides that its violation may be punished by imprisonment, yet in not a single instance has the court imposed any sentence more severe than a fine. And the majority of the fines have been trivial to a degree. A Canton (Ohio) concern was convicted of selling a soft drink containing cocaine. The court considered a $25 fine sufficient punishment. A St. Louis house sold a powder for infants that was said to make "teething" easy; it contained opium. A $10 fine was sufficient punishment. An "agreeable and efficient tonic" was found to contain cocaine, although the presence of this drug was not stated. In this case, the court suspended sentence! Some day, says *The Journal of the American Medical Association*, a court may be found that will consider the crimes of making drug fiends of young people, of poisoning babies with opium mixtures or of killing women with headache powders as more serious offenses than the counterfeiting of the label of a fraudulent "patene medicine." Apparently, that time is far off.